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## **Appendix A: Species Descriptions and Surveys**

### **Aquatic Dependent Species**

The following are brief descriptions of habitat requirements and distributions of aquatic species addressed by the Plan. Species have been grouped by “species associations” that essentially represent species occurrence at the channel reach or segment level. This grouping differs from a traditional trophic or micro-habitat guild approach but it facilitates the association of different species with dominant physical processes that typify various reaches of the channel network. The purpose of grouping the species in this manner is to more clearly tie the effects of management prescriptions and benefits to the species list (Table 12). For example, the headwater species association is subject to scouring effects of debris flows triggered by roads in steep terrain. All of these species would benefit from prescriptions that reduce the incidence of road related debris flows.

#### *Headwater Species Association*

The headwater species association has three species: Olympic torrent salamander, Cope’s giant salamander, and the Tailed frog.

**Olympic torrent salamander (RHOL):** Typically inhabiting loose gravels in the splash zone of steep colluvial or cascade channels, the Olympic torrent salamander is found only on the Olympic Peninsula, WA in small headwater streams and streamside seeps (Nussbaum et. al. 1983).

Surveys: Systematic surveys of 72 small streams in the Plan Area have documented RHOL only in the CUP and exclusively in CUP-C1 channels. None were found in channels with less than 20 percent slope. Anecdotal observations from many other small streams suggest a similar pattern of distribution within the Plan Area. Adults have been captured up to 85 m from these channels in one pit fall trap array on a small tributary to the west branch of Save Creek. Riparian areas associated with this species are often classified as unstable due to steep terrain and streamside seeps.

**Cope’s giant salamander (DICO):** Cope’s giant salamanders are only found in the Olympic Mountains and Willapa Hills of WA and the Coast Range of northern Oregon. They are commonly distributed in moderate to steep headwater streams draining a variety of lithologies and appear to persist in a relatively wide range of micro-habitat conditions. Their distribution overlaps strongly with ASTR and resident cutthroat and to a lesser degree with RHOL.

Surveys: Systematic surveys of 72 small streams in the Plan Area suggest a distribution primarily within the CUP, SIG, and AGL. So far we have been unable to confirm their occurrence in the ROP or the CIS. In the other three LTUs they occur with regularity in small headwater streams with persistent summer flows, and occupy a wide range of habitats but are especially prevalent in channels with gradients of 10-20 percent with coarse cobble substrate and strong summer flows.

**Tailed frog (ASTR):** Tailed frogs are found throughout the Olympic Mountains and Cascades in WA and similar settings in the Coast Range, Blue and Cascade Mountains of Oregon and the Siskiyou and coastal mountains of northern California. Cool streams with coarse gravel and cobble substrates are their principal habitats where the tadpoles graze on diatoms as their principal food source.

Surveys: Systematic surveys of 72 small streams in the Plan Area have documented ASTR in the CUP primarily in CUP-C2 and C3 channels. However, the highest densities we have observed are in Qo1 channels of the SIG. We have also documented their occurrence in similar channel classes in the AGL (AGL-Qo1) and in a single CIS-C1 channel. This latter observation narrows the distance between the Olympic Peninsula populations and the Capitol Forest populations and may represent an isolated group of individuals. In all cases they are associated with coarse gravels and moderate gradient headwater channels.

**Western redback salamander (PLVE):** The Western redback salamander is one of the smallest but most widely distributed of the woodland salamanders, occurring from northern Vancouver Island to southern Oregon west of the cascades. This species inhabits a variety of micro-habitats including moist talus, decaying logs and under moss cover on the forest floor. During periods of wet weather they are surface active but during drier or colder periods individuals retreat to deep cover objects such as porous talus and decaying wood.

Surveys: This species has usually been encountered in all of the systematic surveys of small streams that Simpson has done and is seen with regularity in all LTUs. Limited upland surveys of woody debris and pitfall sampling have also nearly always documented this ubiquitous species.

#### *Steep Tributary Species Association*

The steep tributary species association has two fish species, resident cutthroat trout and shorthead sculpin, and a single amphibian, Van Dyke's salamander.

**Cutthroat trout (resident), (ONCL):** Cutthroat trout are commonly distributed throughout the Pacific Northwest. The species exhibits highly variable life history patterns and inhabitant a wide range of habitat types from small steep streams to ponds and lakes. Resident populations, which are isolated from breeding with sea-run and other resident populations, exist above waterfalls throughout their range. Presumably these populations colonized these stream reaches prior to the complete development of the current blockages but few accurate records of early fish stocking by agencies exist and some introductions were done by settlers.

Surveys: Cutthroat trout are common throughout the Plan Area. However, their distribution in the Plan Area is frequently limited by waterfalls throughout the CUP, SIG, and the AGL above which, resident populations occur but are uncommon.

**Shorthead sculpin (COCO):** Shorthead sculpin are found in many drainages of the Puget Sound and western Oregon and east to Montana through the Columbia River system (Wydoski and Whitney 1979). Little information exists for the species for coastal drainages in Washington. They are considered to be a relatively high elevation species that inhabit cool, fast flowing moderate to small sized tributary streams and show no preference for unit level habitat types (Mongillo and Hallock 1997).

Surveys: In surveys of fish distribution in the Plan Area, the occurrences of shorthead sculpin have been rare. Our observations about their occurrence coincide well with conclusions of Mongillo and Hallock (1997). Principal occurrence is in small steep streams of the CUP.

**Van Dyke's salamander (PLVA):** Van Dyke's salamanders are found only in Washington and within the state their occurrence is fragmented into three primary areas, the Olympic Peninsula, the southern Cascade Mountains, and the Willapa Hills. Van Dyke's salamanders are not truly aquatic species but are more closely associated with streams and water than any of the other

plethodons in the Plan Area. The northern margin of the Plan Area coincides with the southern extent of Van Dyke's distribution on the Olympic Peninsula.

The USFS has accounted for about 150 individuals and several nests in two years of headwater stream and riparian sampling on the Olympic Peninsula. In these surveys the median distance to a water source, usually the stream, is 5 meters with 80% of the occurrences being within 10 meters. Nearly all of the occurrences were down slope of a break in slope between the valley wall and the upslope terrain. Breeding habitat is under the bark of large downed logs and under large loose rock and cobble (Larry Jones pers. communication).

Channel segments in the CUP and steeper segments of the AGL are likely candidates to support Van Dyke's salamanders in the Plan Area. The combination of riparian prescriptions and the prohibition on removal of large residual logs and protection of seeps, which are generally associated with unstable slopes, are expected to provide adequate protection for this species.

Surveys: Systematic surveys of 72 small streams in the Plan Area and many additional anecdotal observations of amphibians have yielded only four observations of PLVA in the Plan Area. Three were in the CUP and the other was near the boundary with the AGL and the CUP. All four were immediately adjacent to streams in saturated but well drained riparian areas.

#### *Flat Tributary Species Association*

The flat tributary species association has eight fish species; coho and chum salmon, sea-run cutthroat trout, the ruffle, reticulate and coast range sculpin, speckled dace, and brook lamprey.

**Coho salmon (ONKI):** Coho salmon are widely distributed in fresh and marine water environments from California to Alaska. Low gradient streams are the most productive for coho and off-channel habitats are important for over wintering of the species.

Surveys: The presence of coho has been widely documented throughout the Plan Area. Especially high quality coho habitat occurs in the Stillwater region of the East Fork Satsop and Schafer Creek in the Wynoochee River. The Satsop river system is known for its late running large bodied coho. Tributary habitat for coho is limited in the West and Middle Fork Satsop and the Canyon River systems.

**Chum salmon (ONKE):** Chum salmon range as far south as the mid Oregon coast and are the second most numerous species of Pacific salmon in commercial fisheries throughout western North America. Over their range they utilize a wide range of stream sizes but typically occupy low gradient gravel rich channels. Their freshwater production is limited by factors that affect the spawning environment as they immediately migrate to sea upon emergence from stream bed gravels.

Surveys: State and tribal biologists annually count spawning chum salmon in streams within the Plan Area. Records of abundance are available back to the mid 1960's in some cases. The gravel-rich low-gradient streams of the ROP and the CIS are highly desirable habitat for chum.

**Cutthroat trout (sea-run), (ONCL):** Sea-run cutthroat trout are widely distributed throughout the fresh and near shore marine waters of the Pacific Northwest. Their numbers have declined precipitously in some areas in recent years. They occupy a wide range of habitat types and display a diverse range of life history strategies making them one of the perhaps more locally adapted species of the salmonidae.

Surveys: Numerous observations of cutthroat occupying habitat within channel reaches also occupied by anadromous fishes have been made. No specific surveys for sea-run cutthroat trout have been conducted however. Principal areas for sea-run cutthroat are the Stillwater River and numerous other tributaries of the East Fork Satsop system.

**Riffle sculpin (COGU):** Riffle sculpin are common throughout coastal river systems in Washington, Oregon, and California. They are mainly found in small to moderate sized tributary streams. Microhabitats include slow riffles and pools with the larger individuals being found in the larger pools.

Surveys: COGU occur in small tributary streams in the SIG above waterfalls as the only fish species. Reasons for this distribution are not fully understood but these populations may have been isolated for many years. As such they have been included as an important species in the HCP.

**Reticulate sculpin (COPE):** The reticulate sculpin is widely distributed in coastal rivers and streams from southern Oregon through Puget Sound streams to the Snohomish River. This species is quite plastic in its adaptation to micro-habitat and is found inhabiting both riffles and pools in moderate to small sized streams.

Surveys: Some of the distinguishing characteristics between the riffle and the reticulate sculpin are difficult to use in the field (e.g. the presence or absence of palatine teeth) and individuals of these two species appear to have many intermediate characters (Wydoski and Whitney 1979). During Simpson's fish surveys, riffle sculpin are routinely encountered but reticulate sculpin appear to be much more uncommon. However, the difficulty in positively identifying these two species may cast some uncertainty on the situation and the reticulate may be much more common than is now appreciated. This species is considered to be an inhabitant of the small to moderate sized tributaries of modest gradient streams in the CIS, the ROP the AGL, and to a lesser degree the SIG.

**Coast Range sculpin (COAL):** Another one of the widely distributed coastal members of the family Cottidae, the coast range sculpin prefers swifter waters of medium to large sized streams. Often it is found in association with the prickly sculpin, which occupies the slower waters of the same stream segments.

Surveys: Simpson has not done directed surveys for this species but coincident with other work has observed them in the larger tributary streams of the SIG.

**Speckled dace (RHOS):** Speckled dace are found throughout the western North America to the Continental Divide. They generally inhabit slower waters than the longnose dace and are sometimes found in lakes and wetlands. Breeding occurs in the early summer when the adults broadcast adhesive eggs over gravel and cobble stream beds.

Surveys: Coincident with surveys of general fish distribution and habitat surveys, Simpson has documented speckled dace in numerous moderated size low gradient streams typically in the ROP and the SIG. In these habitats, this species is frequently found in association with coho salmon.

**Brook lamprey (LARI):** Brook lamprey occur widely in streams of western North America from California to British Columbia and in Washington as far east as the Yakima in the Columbia River drainage. This species spends its entire life in freshwater with the adults reproducing in

small to mid sized streams or in back eddies and sandy locations of larger rivers. The larvae are filter feeders but the adults do not feed during their life phase.

Surveys: Simpson has not conducted systematic surveys for this species but during the conduct of other work has made numerous anecdotal observations that are helpful in describing its distribution. This species tends to most often be found in the sediment rich systems of the SIG and frequently is found upstream from substantial waterfalls and bedrock chutes and cascades in the SIG M and Qc series channels. Spawning occurs in the spring where the adults dig small pits in low gradient riffles where the dominant grain size is small pebbles.

#### *Mainstem Species Association*

The mainstem species association is composed of nine fish and a single amphibian.

**Chinook salmon (ONTS):** Chinook salmon are the largest of the several Pacific salmon species and have a broad range of river entry and spawning timing. Depending on racial characteristics individuals may spend a few months to a full year rearing in freshwater. Maturation age is highly variable with spawning occurring at 2-6 years of age within the same population.

Surveys: State agencies and Indian tribes routinely conduct escapement surveys for chinook salmon in the Plan Area. They are primarily a mainstem spawner in the Wynoochee and Satsop systems but are found in the lower reaches of the larger tributaries.

**Steelhead trout (ONMY):** Steelhead trout are common to coastal and inland river systems of the West Coast of North America. They penetrate watersheds deeply and thrive in small to moderate sized tributaries and mainstem rivers. Steelhead frequently overlap in their distribution with coho but for the most part are able to colonize steeper streams and in their first year of stream residency are less dependent on pool habitat than are coho.

Surveys: The presence of steelhead has been widely documented throughout the Plan Area. Steelhead spawn principally in the spring in the mainstem West and Middle Fork and Canyon River systems and the Wynoochee River. Major tributaries of the Wynoochee and all branches of the Satsop River support populations of steelhead.

**Pink salmon (ONGO):** Pink salmon are the smallest of the Pacific salmon and are unique in that they occur as even age maturing species and occur only in the odd year in Washington. They spend very little time in freshwater, migrating to sea upon emergence from the stream bed.

Surveys: It is unlikely that pink salmon were ever a major fish species in Plan Area channel segments. However, they were common in reaches downstream from Plan Area landscapes such as in the South Fork Skokomish River system.

**Bull trout (SACO):** Bull trout are found in colder headwater reaches of rivers and tributary streams throughout the Columbia River system. Over the last decade research has determined that coastal and some Puget Sound river systems support bull trout as well. However, discrimination of bull trout and dolly varden in field surveys remains problematic.

Surveys: No systematic surveys have been done in the Plan Area for bull trout. However, they are found in headwater reaches of the Skokomish and Satsop rivers and may at some time inhabit Plan Area streams. It is considered unlikely at this time that bull trout consistently reside in the HCP area.

**Dolly varden (SAMA):** Dolly varden are an anadromous char that inhabit rivers along the coast of Washington and Puget Sound. They prefer cooler water temperatures and larger tributaries and mainstem rivers.

Surveys: No systematic surveys have been done for SAMA in the Plan Area. Incidental observations have been made in the south Fork Skokomish River system.

**Torrent sculpin (CORO):** The torrent sculpin is distributed from northern British Columbia south to the Nehalem River in Oregon and east into Idaho and Montana. This species occupies fast riffle habitat and is especially well adapted to life in rapidly flowing waters. They may grow to considerable size (3-4 inches) and age (6 years old). Although this species is primarily an opportunistic feeder of benthic invertebrates it will capture and eat small fish, including salmonid fry.

Surveys: Coincident with surveys of general fish distribution, Simpson has documented the presence of torrent sculpin throughout the Plan Area in larger tributary streams and main rivers, including the Stillwater, West Fork Satsop and Wynoochee Rivers.

**Longnose dace (RHCA):** The longnose dace is found throughout Washington and in other parts of North America as well. This species is particularly well adapted to fast flowing streams and is a benthic feeder. The juveniles spend the first few months of their life in open marginal habitat of their natal stream and with increased size move to deeper faster waters assuming a benthic existence.

Surveys: Coincident with surveys of general fish distribution and habitat surveys, Simpson has documented the presence of schools of juveniles along the margins of mainstem rivers in the Plan Area.

**Pacific lamprey (LATR):** Adult Pacific lamprey are widely distributed throughout marine waters where they are parasitic on fish. In freshwater the ammocoetes are filter feeders and remain buried in soft sand and silt. Adults migrate upstream in the spring and create spawning nests in stream bed gravels.

Surveys: Adult Pacific lamprey have been observed in the large mainstem rivers of the Plan Area and larvae are well distributed both in mainstem and larger tributary environments.

**River lamprey (LAAY):** Adult river lamprey are widely distributed throughout marine waters where they are parasitic on fish. In freshwater the ammocoetes are filter feeders and remain buried in soft sand and silt. Adults migrate upstream in the spring and create spawning nests in stream bed gravels.

Surveys: Adult river lamprey have not been observed in the large mainstem rivers of the Plan Area and their distribution is unknown at this time.

**Western toad (BUBO):** Western toads are widely distributed in a variety of lentic habitats throughout the American west. In some parts of their range their numbers have been on a steep decline. Typically they are an explosive spring time breeder in ponds and small lakes where their larvae feed until metamorphosis in the late summer.

Surveys: In the Plan Area concentrations of riverine breeding western toads have been observed in the Canyon, West and Middle Fork Satsop and Wynoochee Rivers. Breeding occurs from late

May until mid July. Toadlets emerge onto the gravel bars beginning in early August. Mature individuals are found in moist riparian environments on the SIG, especially adjacent to the SIG-L4 channel class where valley width and flood plain complexity are high.

*Lentic Species Association*

The lentic species association is composed of three species of fish and three amphibians.

**Olympic mudminnow (NOHU):** Olympic mudminnow are found in slow moving streams and wetlands with muck substrate, on the western and southern sides of the Olympic Peninsula, occurring north of the Chehalis River. Often they are associated with habitats that have thick aquatic vegetation. Recently NOHU have been found in the Lake Washington watershed, expanding their known range.

Surveys: No systematic surveys have been done for NOHU in the Plan Area but Simpson has identified several wetlands and sluggish stream systems that support them.

**Prickly sculpin (COAS):** The prickly sculpin is widely distributed along the coast of North America and occurs in the slower water habitats of medium sized streams and lake and wetlands. This species is tolerant of a wide range of salinity and may occur in coastal estuarine settings as well as freshwater.

Surveys: Coincident with surveys of general fish distribution, Simpson has documented the presence of the prickly sculpin in wetlands and slack water streams of the ROP.

**Three-spine stickleback (GAAC):** Three-spine stickleback are one of the most widely distributed fish of all, occurring in marine and fresh water environments in North America and Asia. In the Pacific Northwest they occupy a variety of habitat niches and possess a highly variable array of behaviors and life history traits to accommodate environmental differences.

Surveys: Simpson has not conducted any directed surveys for this species but coincidental to general fish distribution surveys has discovered them in numerous slack water streams and wetlands. Most of our observations have been in the ROP and often this species is in close association with dense vegetation. More often than not, Olympic mudminnow are also present where three-spine stickleback are found in the Plan Area.

**Northwestern salamander (AMGR):** The Northwestern salamander is found along the Pacific coast from northern British Columbia to northern California to just beyond the Cascade crest. Breeding occurs in ponds in the early spring with gelatinous eggs masses attached to submerged stems and vegetation. Larval development slow with metamorphose usually occurring after a full year of pond residence. Terrestrial adults inhabit moist forest and valley bottom environments.

Surveys: Stream adjacent pitfall traps operated by Simpson in the ROP and the SIG have occasionally captured this species as have systematic surveys of small streams in the SIG. Limited wetland surveys with dip nets and minnow traps have also documented their presence at wetlands in the ROP.

**Long-toed salamander (AMMA):** The long-toed salamander is distributed from Alaska to California and east to western Montana. This species is observed infrequently in spite of its wide distribution due to their largely subterranean existence. Eggs are attached to subsurface structural

elements such as twigs or stems of submerged vegetation in ponds and wetlands. Larval development is rapid and metamorphosis is usually attained by early summer at low elevations.

Surveys: Stream adjacent pitfall traps operated by Simpson in the ROP have occasionally captured this species and limited wetland surveys with dip nets and minnow traps have also documented their presence at wetlands in the ROP.

**Red-legged frog (RAAU):** Red-legged frogs are a relatively large amphibian and inhabit a wide range of moist forest and valley bottom habitat from British Columbia to northern California. This species typically breed in ponds but may breed in river backwaters with no velocity. Eggs are attached to underwater structures most commonly stems of vegetation or twigs and branches of downed vegetation. In the summer they may be found considerable distances from water but with increasingly dry summer conditions, congregate at the edges of streams and wetlands.

Surveys: No directed surveys for this species have been conducted in the Plan Area but the red-legged frog has been one of the most commonly observed aquatic vertebrate species. Simpson has documented their presence in habitats as diverse and widely separated as small streams in the CUP to wetlands in the ROP.

### **Wildlife Species that are not Dependent on Snags**

#### **Marbled Murrelet (*Brachyramphus marmoratus*)**

Marbled murrelets inhabit the Pacific Ocean, and in Washington and Oregon, they nest in mature or old-growth forests typically below 3,000 feet elevation (Marshall 1988, Paton and Ralph 1988). The nests are on tree platforms that are at least 7 inches across and have some overhanging protection (Ralph et al. 1995). Moss is typically present on the nest substrate, and the nests are typically in the highest one third of the tree. In order for stands to provide good murrelet nest habitat they need to be relatively easy to access with fast (approx. 40 mph) flights such as uneven-aged and multi-layered forest canopies. These stands also typically have vegetative hiding cover such as vertical cover over the nest and horizontal cover around the nest site which reduce predation from jays, crows and ravens. Horizontal vegetative cover also reduces the chances of wind disturbance to the nest.

Murrelets will incubate one egg during a nesting season that generally extends between May 1 and August 15 (Ralph et al. 1995). They will make daily flights to salt water to obtain forage for them and their chick, and these flights typically occur during early morning and late evening periods.

Species Surveys: Marbled murrelet habitat that was entirely or partially outside the RCR was surveyed in 1998 with ten surveys. These survey sites will be surveyed again in 1999 to complete two consecutive years of surveys of ten surveys each year, for each survey site.

Habitat Inventories: Marbled murrelet nesting habitat in the HCP area (and other Simpson Northwest lands) was assessed in 1994. A total of 1,138 acres of habitat were found to be present during the 1994 murrelet nest habitat inventory. This habitat was in 38 separate areas, with an average stand size of 30 acres and an average age of 226 years old. These habitats were mapped using Simpson GIS and documented in Figure 5 of this HCP. The following describes the inventory process and criteria.

*Step 1:* The first step in this assessment process consisted of searching through the forest stand data for stands that met the following criteria.

- stand age 80 years or older
- stand size greater than 5 acres in size
- dominated by conifers (greater than 50 percent)
- any other areas identified by Simpson that may contain large conifer trees with well developed crowns

The forest inventory data used in this process included: stand age, species composition (percent), acres, and site class. A total of 618 timber management units were identified as meeting these criteria.

*Step 2:* Stands meeting the criteria in Step 1 were reviewed to determine the chances that they may be potential nesting habitat. Aerial photos and a magnified stereoscope were used in this process when assessing the following criteria.

- crown size - large developed crowns which had a likelihood of having suitable platforms
- canopy openings - stands with openings or gaps in the canopy providing access to potential nest sites
- topography - stands with topographic relief provide greater opportunities for access for relatively dense stands

Each of the 618 management units was classified into one of the following three categories as a result of this assessment:

1. highly likely to contain suitable habitat (platforms)
2. possibly containing suitable habitat
3. obviously not suitable habitat

*Step 3:* All of the areas identified as Categories 1 and 2 (in Step 2) were then further evaluated with walk-through inspections. Some stands in isolated areas and some riparian stringers of mature forest were inspected from helicopter. A portion of the stands (approximately 20 percent) in category 3 were also ground truthed to verify that they indeed did not contain suitable habitat. The following questions were used when evaluating each of the stands during Step 3:

- Are platforms (large limbs, mistletoe brooms, defects, limb branching and whorls, defects, etc.) present that are at least 7 inches wide by 7 inches long in live conifer trees? (The presence of moss was not a requirement to be considered as a platform but was noted).
- Are these platforms are at least 50 feet above the ground?
- Are there at least 2 platforms per acre present in the stand?

*Step 4:* Stands with suitable platforms meeting the above criteria were further evaluated using the following qualitative factors:

- Canopy closure - Are platforms accessible to murrelets flying into the stand. Accessibility was considered restricted if the platforms were on limbs that were below a very dense canopy that murrelets could not access (generally greater than 90 percent canopy closure average for the entire stand was used). However, if a stand with high canopy closure also contained areas with small openings or gaps in the canopy, permitting marbled murrelets to enter the stand and access these platforms, then they were considered suitable habitat if they met other criteria in Step 4. In addition, topographic relief was also considered for accessibility.
- Width of the stand of trees, break of habitat, and amount of edge or interior forest present - Generally a break in the stand (forest containing trees with similar characteristics) of 300 feet or more was considered a break in habitat. In addition, some linear strips of trees containing thin stringers of residual old trees less than 300 feet wide and greater than 300 feet long were generally not considered as a stand of habitat due to the high degree of exposure (edge).
- Exposure - Platforms in open stands (typically stands with less than 40 percent canopy cover of dominant and codominant conifer trees) are more exposed to predation and weather (wind,

rain, temperature, etc.), therefore influencing whether the stand was considered as habitat. This assessment took into consideration the amount of overhead cover and cover from adjacent trees. Single large trees within a heavily dominated stand of deciduous trees (maple, alder, and cottonwood), rising 80-100 feet above these deciduous trees were not included as habitat.

Some stands met criteria in Step 3, but were not considered habitat because they did not meet the criteria in Step 4. The following are three examples of types of stands.

1. Riparian stringers of residual older-aged conifers with potential platforms were present along some of the major rivers in the HCP area. These thin strips of forest were generally only 50-200 feet wide. For example, several portions of the Wynoochee River contain thin stringers of large residual conifers along the stream channel. These linear strips contain individual or small groups of 2 to 3 conifers, generally every 50 to 400 feet. Other trees within these riparian strips were typically much younger conifers and deciduous trees, providing little or no horizontal screening or cover to the much taller residual conifers. Additionally, the upland portion of these riparian stringers were typically bordered by young conifer plantations, which provided virtually no horizontal screening to potential platform trees. These riparian strips also were typically separated by 100 - 300 feet of river and associated gravel bars, which created additional open areas and increased edge exposure. Although trees with potentially suitable platforms were present, they were severely exposed to predators and adverse environmental conditions (higher ambient temperatures, winds, and exposure to rain, etc.). Based on the literature, the amount of edge and exposure are important factors in determining the quality of nesting habitat of a stand (Ralph et al. 1995; USFWS 1998). An important note about these riparian stringers is that most are located within RCRs, which will be conserved as part of the HCP.
2. Another example of stands that met Criteria in Step 3 but not criteria in Step 4 were deciduous dominated stands with a few large remnant older conifer trees, some with potential platforms. These areas were typically found in riparian areas of major streams, such as the Wynoochee River and the major forks of the Satsop River. These stands were dominated by deciduous trees, but contained single or small clumps of older-age coniferous trees (2 - 3 trees) that were 50 - 200 feet apart. The crowns of these conifers were typically well above surrounding deciduous trees, and there was little horizontal screening or cover to protect potential nest sites from predation. Again, almost all of these areas were located within RCRs, which will be conserved as part of this HCP.
3. The third example of stands that were not considered murrelet habitat were coniferous stands containing conifer trees with platforms (typically mistletoe booms in western hemlock) that were in dense stands with a high canopy cover (greater than 90 percent for the stand). Very few, if any, gaps in the canopy were present in these stands. These stands were located on relatively flat areas also reducing exposure of individual tree canopies. As a result, it is virtually impossible for a marbled murrelet flying 50 miles per hour or more to access platforms within these dense, single canopy layer stands. These areas were typically were located in upland areas outside RCRs.

*Step 5:* During 1997 murrelet habitat in the HCP area was classified into survey sites in preparation for the murrelet species surveys in 1998. As part of this process, potential habitat on ownerships adjacent to habitat on Simpson lands also was evaluated to determine if it should be included as continuous suitable habitat. The inventory results from 1994, also were further

examined in 1997 and 1998, as part of this HCP project, to ensure decisions made from the 1994 inventory still apply.

**Bald Eagle (*Haliaeetus leucocephalus*)**

The bald eagle is found in and around the HCP area throughout the year. It primarily nests in coniferous uneven-aged stands with old-growth tree components, with a low level of human disturbance and an abundance of prey (Anthony et al. 1982, Livingston et al. 1990). Nest building begins as early as January or February with egg laying initiated in March or early April, and fledging occurring in July. Nest trees typically are in older and large (greater than 32 inches DBH) dominant or co-dominant trees with large limb structures capable of holding the large nests.

Bald eagle communal roosts are any stand of trees in which eagles regularly roost together. Bald eagles often roost communally during the night, especially during late fall, winter and early spring. They also will communally use these areas during daylight hours. Staging areas are stands of trees near communal roosts where eagles gather before and after flights to and from the roost.. Roost site management plans typically divide roost sites into core areas and buffers zone designations for management purposes.

Surveys: Formal or comprehensive surveys of bald eagles and their nest sites have not been conducted in the HCP area. One communal roost site has been verified to exist, and it is located on the steep valley side slopes of the North Fork Skokomish River, near the confluence with the South Fork Skokomish River. This site supports approximately 30 bald eagles primarily during September to February each year.

**Band-tailed Pigeon (*Columba fasciata*)**

The Pacific coast population of band-tailed pigeons occurs from British Columbia to Baja, California, and within most western states (Urdvardy 1977). Band-tails winter from southern California and Arizona through Central America (Terres 1991). They inhabit areas from sea level to timberline and are believed to occur throughout the HCP area.

The band-tailed pigeon nests in mature or old-growth coniferous and coniferous/deciduous forests, and they use dominant trees for calling and display flights. Nesting occurs from May through July with an 18-20 day incubation period. Band-tails usually nest in scattered pairs, but occasionally will nest in “colonies” in one tree (Terres 1991). Nests have been found 8 to 40 feet or more from the ground in coniferous and deciduous trees (Terres 1991). Preferred forage species are seed and berry producing shrubs and trees, such as: cascara, elderberry, and blackberry. Calcium and possibly other minerals derived from mineral springs are believed to be important to this bird immediately before and during breeding and nesting season (Terres 1991).

Annual censuses of these birds coordinated by the USFWS have shown the population declined significantly during the past 10 years. This decline is possibly due to a combination of the following factors: 1) loss of winter habitat; 2) loss of foraging habitat due to land use and herbicide spraying; and 3) over hunting.

Surveys: Some small scale sampling has been accomplished for this species in the HCP area, as part of the Washington State-wide annual voluntary bird census conducted by the Audubon Society and other groups. Band-tails are found each year in the HCP area, during these surveys, however the small extent of this survey and the limited number of years in which it has been conducted do not provide reliable estimate, at this time, of long-term population trends in the HCP area.

**Harlequin Duck (*Histrionicus histrionicus*)**

Harlequin ducks winter offshore along the Pacific coast from eastern Siberia and Alaska to northern California (Erlich et al. 1988). In the summer they breed on rocky coastal islets and along inland rivers as far east as the Sierra Nevada and northern Rocky Mountain ranges (Urvady 1977).

The harlequin typically nests within 90 feet of fast-flowing streams from April through June (Ehrlich et al. 1988). Nests usually occur in scrapes on the ground and sometimes in tree cavities, low branches or on other low vegetation structures. Nests are usually protected by rocks or shrubs and lined with leaves and down. Harlequins show fidelity to nest sites, but they are unlikely to return if significantly disturbed (Wallen and Groves 1989). Nesting usually occurs in May with 5-10 cream colored eggs (Ehrlich et al. 1988). Incubation is usually 30 days and the young fledge 35-40 days after hatching. Broods remain near nests for a few weeks after fledging, and they move downstream during the summer (Wallen 1987). Broods prefer low-gradient streams (Begton and Ulfstrand) and have been associated with mature and old-growth coniferous forests (Cassirer and Groves 1990).

The harlequin preys on crustaceans, mollusks and aquatic insects (Cotton 1939). They move along the bottom of food-rich fast-flowing streams foraging among the rocks (Ehrlich et al. 1988). Loafing sites along streams are also important places to rest between forages (Cassirer and Groves 1990).

Surveys: The HCP area includes some optimum habitat for this species, although surveys for this species have only been done sporadically and along only some stretches of the river. The Washington state data base has one historical record of a harlequin in the HCP area in 1961 (T10S R09W Sec. 30). This species also has been seen on the Satsop and South Fork Skokomish Rivers during surveys conducted by the Washington State DFW during recent years..

**Roosevelt Elk (*Cervus elaphus Roosevelti*)**

Roosevelt Elk (CEEL): Roosevelt elk is one of four subspecies of elk remaining in North America and it is found from Vancouver Island, British Columbia to Northern California and west of the Cascade crest. This species was included within this HCP due to the high level of public and tribal interest and because populations are substantially below carrying capacity levels in some portions of the HCP area.

Roosevelt elk forage on herbaceous (grasses, sedges, forbs and ferns) plants, particularly in the spring through fall, and woody plants, such as shrubs and young trees. They rely on vegetative cover for hiding and to a less extent on external thermal regulation. Elk home ranges vary from approximately 500 to 2,000 acres depending on herd size, quality of habitat, season and harassment. This species can thrive in industrial forest lands; however, intentional and unintentional harassment from humans on roads tends to be the biggest threat to its existence and population health in these types of areas. Elk are pursued as a prime game species, and they are very susceptible to illegal hunting in areas with high amounts of road mileage.

Surveys: The Washington State Department of Fish and Wildlife has periodically conducted surveys during the last ten years in the HCP area (Schirato pers. comm. 1996). These surveys have produced only general population estimates of some of the elk herds in the HCP area. Results indicate there are approximately 7 herd territories in the HCP area, and some herds tend to be broken into numerous subgroups, rather than consistently being together.

Surveys conducted by the Point No Point Treaty Council included approximately the northern one third of the HCP area, as well as areas north and west of the HCP area (Nickelson et al. 1995, Nickelson and Anderson 1997). Results of these surveys show the portion of the HCP area north of the Shelton-Matlock, Deckerville and Cougar Smith roads has 78-162 elk, which is believed to be substantially below the number of elk that area could support. The Treaty Council surveys also found very few elk (only 30 found) in an area approximately 60,000 acres in size immediately north of the HCP area (Nickelson et al. 1995). Comprehensive surveys have not been conducted for elk in the southern half of the HCP area.

### **Snag Dependent Species**

The following wildlife species are dependent on snags for a major portion of their life requirements for nesting, roosting, or foraging. Snags, within this context, are standing dead or partial dead trees. There is wide variability in these types of trees; however, they all have significant death, structure decay or structural defect (e.g. broken top, dead top, all limbs without life or a significant portion of the limbs without life, and large defects in the tree bole or major limbs leading to cavities in the structure). Other species addressed by this plan may also utilize trees with defects for some minor portions of their life requirements; however, they do not provide a major portion of their needs. Those species are not included here since their life requirements are not dependent on snags.

All of the snag dependent species listed below range throughout the Pacific Northwest, and some species are wide ranging over major portions of North America while others have a more limited range. Our focus here is on those species which are present within the HCP area or have a likelihood of occurring there. A brief description of each species life requirements, nesting and foraging habitats, and known distribution in the Plan Area are described below. Simpson has not requested ITP coverage for some species that are described in this Appendix; however, those descriptions have been included in the event that Simpson considers their coverage in the future. Table 24, in this appendix, summarizes the most pertinent habitat needs of these species.

Surveys: The snag dependent species addressed by this plan have generally not been censused with a systematic and scientifically designed approach. Some on-going annual bird census surveys do record some of these species, however these general surveys are typically best suited for song bird census. These annual bird censuses have been conducted by volunteers during past years along major roads, and within small portions of the HCP area. These censuses have not been developed to specifically survey snag dependent species addressed by this HCP. These species often have unique behaviors and vocal patterns that require unique survey approaches to obtain reliable trend data.

Spotted owl surveys conducted from 1990 to 1993 in many portions of the HCP also include data for other owl species, such as saw-whet, screech, pygmy and barred owls (Simpson Timber Company, unpublished data, 1990-1993). The biologists collecting the spotted owl data were trained in identifying other owl species and they were required to record those detections. At some later point Simpson may organize and summarize that data and present it to the Services for their review.

### **CLASS 1 - SNAG DEPENDENT SPECIES**

#### **Downy woodpecker (*Picoides pubescens*)**

This species inhabits deciduous, coniferous, and mixed forest types, typically at least 40 years old (Thomas et al. 1979; Brown 1985). They utilize both interior forests and edges for nesting and

foraging. They excavate their cavity-nests near the tops of snags or dying trees, preferring trees 11 inches dbh and 10 feet tall located in fairly open tree stands (Scott et al. 1977; Brown 1985). They also nest in live trees, especially if heart-rot is present. Generally they excavate new cavities each year, often in the same tree (Hardin and Evans 1977) and seldom uses old cavities or those made by others species (Thomas et al. 1979). They forage mainly on beetles and wood-boring larvae, and on fruits and seeds (Beal 1911) by digging in the bark with their bill, gleaning along the bark surface, and infrequently by flycatching (Jackson 1970). This species is present in the Plan Area.

**Black-capped chickadee (*Parus atricapillus*)**

They are locally common in the Action Area, found in open habitats, in young deciduous and mixed conifer forests that are typically at least 11 years old, in riparian forests, and along forest edges (Sturman 1968; Thomas et al.; DeGraaf et al., 1991; Nickell 1956). Willow, alder, and cottonwood trees are the most common nest trees in Washington (Jewett et al., 1953). They nest in natural cavities, abandoned woodpecker cavities, or excavate cavities in soft snags and tree stubs that are typically 9 inches dbh and at least 10 feet tall (DeGraaf et al. 1991; Raphael and White 1984; Brown 1985; Thomas et al. 1979). They forage by gleaning insects from the bark of tree trunks and logs, in addition to fruit and seeds (Brown 1985).

*CLASS 2 - SNAG DEPENDENT SPECIES*

**Western bluebird (*Sialia mexicana*)**

This neo-tropical migrant species is found in open forests where they are adjacent to grasslands and shrublands. They are not common in western Washington and have been documented in the Plan Area (Smith et al. 1997). They require cavities for nesting, often using old woodpecker cavities (Rodrick and Milner 1991). They utilize mature forest edges (generally at least 80 years old), nesting in cavities in trees typically 15 inches dbh and 10 feet tall (Bent 1942; Erlich et al. 1988). They will also utilize nest boxes where cavities are limited. Competition from other species such as more aggressive starlings (*Sturnus vulgaris*) and other native bird species can severely limit bluebird nesting in artificial structures. They forage primarily by “hawking” insects from a low perch in grasslands, shrublands, riparian areas, cliffs, and talus areas (Thomas et al. 1979). They will also utilize clearcuts with snags present.

**Purple martin (*Progne subis*)**

This neo-tropical migrant species is found at the edges of mature forests that are typically at least 40 years old and adjacent to lakes, ponds, and wetlands where standing trees and in or near water (Brown 1985; DeGraaf et al. 1991). They nest in abandoned woodpecker cavities in snags and live trees with defects generally 15 inches dbh and 10 feet tall (Marshall et al. 1992). These colonial nesters also utilize cavities in cliffs and crevices in old buildings, and will readily use nest boxes near existing colonies (Rodrick and Milner 1991; Brown 1985). They typically forage over open water for insects on the wing (Erlich et al. 1988) and uses all seral stages of riparian and wetland forests as foraging habitat (Brown 1985). This species occurs in the Plan Area at Lake Nahwatzel.

**Chestnut-backed chickadee (*Parus rufescens*)**

In western Washington this species is typically found in mature coniferous forests with a high percentage of overstory canopy cover. It also is found in deciduous and mixed conifer forests (Sturman 1968; Thomas et al. 1979; Jewett et al. 1953; Melow and Wight 1975; DeGraaf et al. 1991; Nickell 1956). They nest in natural cavities, abandoned woodpecker cavities, or excavate cavities in soft snags and tree stubs. Lundquist and Mariani (1991) found this species typically nesting in trees that average 37 inches dbh in the southern Washington Cascade mountain range,

although other research has shown nest trees can vary from 9 to 41 inches DBH (Degraaf et al. 1991; Raphael and White 1984; Brown 1985; Thomas et al. 1979). This species forages by gleaning insects from the bark of tree trunks and logs, in addition to fruits and seeds (Brown, 1985).

**Red-breasted sapsucker (*Sphyrapicus ruber*)**

This neo-tropical migrant species is found in a variety of habitats typically found in conifer and mixed conifer forests generally greater than 40 years old in western Washington (Brown 1985). Forests adjacent to wetlands and riparian areas are preferred (Thomas et al. 1979). They excavate cavities in dead snags and tops of live trees typically 15 inches dbh and 20 feet tall (Brown 1985). They forage for insects by drilling holes in live trees and snags and by gleaning bark (Beal 1911; Bent 1939). This species is likely present in the Plan Area.

**Tree swallow (*Tachycineta bicolor*)**

This neo-tropical migrant species inhabits open mature forests typically at least 80 years old, adjacent to open areas such as grasslands, shrublands, open water, and wetlands where standing trees or snags are near water in western Washington (Brown 1985; DeGraaf et al. 1991). In the Blue Mountains of Oregon this species typically utilized forests that were at least 40 years old adjacent to similar habitats (Thomas et al. 1979). They nest in abandoned woodpecker cavities in snags and live trees with defects that are generally 15 inches dbh and 20 feet tall (Brown 1985; Marshall et al. 1992). If cavities are limited they will readily use nest boxes or nest in crevices of buildings (Bent 1942; Scott et al. 1977). Although tree swallows are not colonial nesters, they will nest within seven feet of each other if there are adequate wetland areas or open water for foraging (Whittle 1926). They typically forage over open water for insects on the wing but also feed on seeds and berries more than other swallows (Scott et al. 1977). This species is likely present in the Plan Area.

**Violet-green swallow (*Tachycineta thalassina*)**

This neo-tropical migrant species inhabits open mature and riparian forests typically at least 80 years old, adjacent to open areas in western Washington (Brown 1985; DeGraaf et al. 1991). In the Blue Mountains of Oregon this species typically utilized forests that were at least 40 years old adjacent to similar habitats (Thomas et al. 1979). They are found along edges of dense woodlands adjacent to open areas such as grasslands, shrublands, open water, and wetlands where standing trees or snags are near water (Brown 1985; DeGraaf et al. 1991). They nest in abandoned woodpecker cavities in snags and live trees with defects generally 15 inches dbh and 20 feet tall (Brown 1985; Marshall et al. 1992). They also nest in rocky cliffs, burrows of bank swallows, niches of buildings, and nest boxes if cavities are scarce (Bent 1942; Scott 1977). They forage for insects taken on the wing (Scott et al. 1977) and are present in the Plan Area.

**Hairy woodpecker (*Picoides villosus*)**

This species inhabits open coniferous, deciduous, and mixed forest types, typically at least 40 years old, with snags mature living trees and wooded swamps (Thomas et al. 1979; Brown 1985). They prefer bottom land areas with large trees (DeGraaf et al. 1980) and are generally more abundant at the edge of woodlands (DeGraaf et al. 1991; Zarnowitz and Manuwal 1985). Hairy woodpeckers in Washington are found in open rather than dense stands of timber (Larrison and Sonnenberg 1968). They excavate their cavities in soft snags or live trees that are typically 15 inches dbh and 20 feet tall with decaying heartwood (Conner et al. 1975; Brown 1985; Sousa 1987). They are opportunistic foragers (Raphael and White 1984), foraging on a variety of substrates including tree trunks, stumps, exposed roots (Lawrence 1966), snags, downed logs, the ground (Mannan et al. 1980), and logging debris in recent clearcuts (Conner and Crawford 1974). They forage mainly on beetles and wood-boring larvae by drilling or gleaning from the bark and

on fruits and seeds (Raphael and White 1984; Beal 1911). This species is present in the Plan Area.

**Western screech owl (*Otus kennicottii*)**

This species prefers open forests of all types, and riparian forests adjacent to meadows, grasslands, and other openings (DeGraaf et al. 1991; Thomas et al. 1979; Brown 1985). They nest in mature forests that are typically at least 80 years old in natural cavities and abandoned woodpecker and flicker cavities in trees and snags that are frequently greater than 17 inches dbh and 20 feet tall (Brown 1985). They will also use nest boxes where cavities are scarce (Hammerstrom 1972). Screech owls hunt for rodents, insects, amphibians, and small birds in grassy openings, or along field margins or streams. This species is present in the Plan Area.

**Northern pygmy owl (*Glaucidium gnoma*)**

This species inhabits deciduous, conifer, and mixed open forests that are typically at least 40 years old with scattered trees in western Washington (Brown 1985; DeGraaf et al. 1991; Thomas et al. 1979). They utilize forest edges for both nesting and foraging (Brown 1985). They nest in natural cavities and abandoned woodpecker and flicker cavities in trees and snags that are frequently greater than 17 inches dbh and 30 feet tall (Brown 1985). They prey upon rodents, insects, amphibians, and reptiles in open areas. This species is present in the Plan Area.

**Northern saw-whet owl (*Aegolius acadicus*)**

This species is found in most forest types, but favors dense closed-canopy forests generally at least 80 years old and swampy areas of coniferous and deciduous forests (DeGraaf et al. 1991; Brown 1985). They nest in natural cavities, and those made by woodpeckers and flickers in trees and snags that are frequently greater than 17 inches dbh and 20 feet tall (Brown 1985; Scott et al. 1977). They also will use nest boxes if saw dust or straw is provided (Hammerstrom 1972). Prey species include small mammals, small birds, insects, and frogs (DeGraaf et al. 1991). This species is present in the Plan Area.

**Northern flicker (*Colaptes auratus*)**

This species is a common resident in the Plan Area found in all forest types. They forage in open forests, edges, and openings with nearby dense forests that are typically at least 40 years old (DeGraff et al. 1980; Thomas et al. 1979). They prefer to excavate their cavities for nesting in soft snags or near the top of live trees that are 17 inches dbh and 10 feet tall (Brown 1985). They will also nest in cavities excavated by others and in nest boxes (DeGraff et al. 1980; Thomas et al. 1979). A large portion of their time is spent foraging on the ground in open areas for ants, other insects, fruits, and seeds.

**CLASS 3 - SNAG DEPENDENT SPECIES**

**Pileated woodpecker (*Dryocopus pileatus*)**

This species can be found in younger-aged second-growth forests typically at least 40 years old with many large snags and logs (Mellen et al. 1992); however, they are typically found in mature forests that are older than 80 years old and in old-growth forests with two or more canopy layers (Bull et al. 1990; Rodrick and Milner 1991; Thomas et al. 1979; Brown 1985). They excavate cavities for roosting and nesting in large snags and trees that are typically 25 inches dbh and 40 feet tall, often in trees with decadent branches or stems (Brown 1985; Bull et al. 1990). Most nest trees are hard snags with bark and broken tops. Each pair excavates one or more domed-shaped nest cavities (4 to 5 inches high and 3 to 4 inches wide) per year. Unused or old nest cavities may be used for night roosts, individual birds using up to eight cavities (Raley pers. comm. 1993).

Pileateds forage for carpenter ants and other insects by gleaning and excavating in snags, live trees, stumps, and downed logs. This species is present in the Plan Area.

**Wood duck (*Aix sponsa*)**

This species inhabit streams, lakes, ponds, and wetlands (Bellrose 1976). They typically are found in mature at least 80 years old and old-growth conifer and mixed forests that are near water (Bellrose and Holm 1991). Wood ducks utilize natural cavities or those abandoned by woodpeckers in defective trees and snags that are generally 25 inches dbh and 10 feet tall (Bellrose and Holm 1991; Brown 1985). Where cavities are limited, they readily nest in artificial boxes if protected from predators (Bellrose et al. 1964). They forage on the ground or in water on plants, seeds, fruits, and invertebrates (Landers et al. 1977). This species is present in the Plan Area.

**Common merganser (*Mergus merganser*)**

This species prefers clear, cool ponds associated with upper portions of rivers and clear freshwater lakes with forested shorelines (Johnsgard 1975). They usually nest in mature forests generally at least 80 years old, nesting in natural cavities in trees and snags that are typically 25 inches dbh and 10 feet tall (Brown 1985; DeGraaf et al 1991). Unlike other cavity-nesters they do not use abandoned woodpecker cavities. Tree species and height may not be extremely important (Foreman 1976). Although tree nests are typically chosen, ground nests under thick cover or in rock crevices are not uncommon (Scott et al. 1977). They will also use a wide variety of other locations such as nest boxes, chimneys, hawk nests, bridge supports, and old buildings (Scott et al. 1977). Nests are typically within 100 feet of water (Palmer 1976). They forage in shallow waters (1 to 6 feet deep) primarily on a wide variety of fish, although they also feed on amphibians, crustaceans, insects, and plants (Palmer 1976). This species is present in the Plan Area.

**Table 24. Snag dependent wildlife species that inhabit or could inhabit the Simpson HCP area, and their habitat requirements.**

Class <sup>a</sup>	Species	Snag/Tree Description				Snag Abundance (#/acre)	Habitat type and location <sup>c</sup> F=foraging habitat R=reproductive habitat
		Average size of snag (reference shown in superscript) dbh (inches)      Height (feet)		Minimum size of snag <sup>b</sup> (reference shown in superscript) dbh (inches)      Height (feet)			
1	Downy woodpecker	8-11 <sup>1,16,24</sup>	20-43 <sup>20</sup>	6 <sup>2</sup>	10 <sup>1</sup> , 15 <sup>2</sup>	1 <sup>51</sup> 1.6 <sup>1</sup> 3 <sup>2</sup>	excavates cavities in hard/soft snags and trees, prefers deciduous trees, found in all wooded habitats deciduous/conifer, riparian areas, adjacent to wetlands and lakes F/R 40+ yr old forests <sup>1,2</sup>
1	Black-capped chickadee	9 <sup>1</sup>		4 <sup>2</sup>	6-10 <sup>1,2</sup>	2 <sup>48</sup>	open habitats, young forests adjacent to wetlands, edges F- open areas, shrub, open water, wetlands, feeds by gleaning throughout the canopy in forests 11+ yr old <sup>1,2</sup> R- young forest 40+ yr old <sup>1</sup> edges adjacent to wetlands, utilizes stumps
1	Chestnut-backed chickadee	9 <sup>1</sup> , 25-30 <sup>24,16</sup> , 37-40 <sup>6,7</sup>		4 <sup>2</sup>	6-10 <sup>1,2</sup>		excavates cavities in soft snags open habitats, young forests adjacent to wetlands, edges F- open areas, shrub, open water, wetlands, feeds by gleaning throughout the canopy in forests 11+ yr old <sup>1,2</sup> R- young forest 40+ yr old <sup>1</sup> edges adjacent to wetlands, utilizes stumps
2	Western bluebird	15-19 <sup>1,4,6</sup>		10 <sup>2</sup>	6-10 <sup>1,2</sup>		edge species - forest edges and open areas F- grass, shrub, wetlands, cliffs, talus R- 40+ yr old conifer/mixed/deciduous forest, nests in cavities in trees adjacent to openings, prefers class 5 snags, utilizes stumps, and nest boxes
2	Purple martin	15-21 <sup>1,4</sup>			10 <sup>1</sup>		within 200' of wetlands in mature forests (40+ <sup>1</sup> ), edges adjacent to lakes and ponds F- over open water and wetlands R- trees, snags, and nest boxes

**APPENDIX A: SPECIES DESCRIPTIONS AND SURVEYS**

2	Red-breasted sapsucker	15-30 <sup>1,6</sup>			20 <sup>1</sup>	0.5 <sup>1</sup> 0.6 <sup>41</sup>	excavates cavities in hard snags/trees, found in a variety of habitats - mixed/conifer forests F- 40+ yr old forests <sup>1</sup> , mostly gleaning insects on live trees, some drilling and flycatching R- 40+ yr old forests <sup>1</sup> , dead tops of live trees are important for nesting (class 4) but not class 6 snags
2	Tree swallow	15-19 <sup>1,4,24</sup> , 25 <sup>16</sup>		15 <sup>2</sup>	10-20 <sup>1,2</sup>		deciduous/mixed/conifer forests, riparian forests, open areas (grass, shrub), wetlands F- above water, grass, shrub, meadows, forests R- 40+ yr old forests <sup>2</sup> and 80+ yr old forests <sup>1</sup> , nest boxes, in soft snags (class 6)
2	Violet-green swallow	15-20 <sup>1,4</sup>		15 <sup>1</sup>	10-20 <sup>1,2</sup>		mixed open forests and riparian areas F- above water, grass, shrub, meadows, forests R- 40+ yr old forests <sup>2</sup> and 80+ yr old forests <sup>1</sup> and in buildings
2	Hairy woodpecker	14-17 <sup>1,4,8,12,24,50</sup> , 21-23 <sup>16,33</sup> , 29-36 <sup>6,7</sup>	30-59 <sup>8,10,12,20</sup> , 66-95 <sup>6,9,33</sup>	10 <sup>2</sup>	15-20 <sup>1,2</sup>	1.8 <sup>2</sup> 1.9 <sup>1</sup> 2 <sup>50</sup> 6 <sup>44</sup>	excavates cavities in soft snags, found in all wooded habitats deciduous/conifer, riparian areas, adjacent to wetlands and lakes F- 40+ yr old forests <sup>1,2</sup> , gleans insects and drilling on trunk R 40+ yr old forests <sup>1,2</sup> , prefers soft snags (class 4+)
2	Western screech owl	17 <sup>1</sup>		12 <sup>2</sup>	15-20 <sup>1,2</sup>	0.4 <sup>49</sup>	woodland habitats near open areas, riparian areas, also farmlands and urban habitats F/R- nests in hard snags/trees along edges between grass, shrub, open forests of all ages snags, cliffs, talus, also cavities in banks and cliffs, may nest in forests 40+ yr old <sup>2</sup> and 80+ yr old deciduous/mixed, riparian forests <sup>1</sup>
2	Northern pigmy owl	17 <sup>1</sup>		12 <sup>2</sup>	30 <sup>1,2</sup>		semi-open habitats, all forest types of all ages F-edges between grass, shrub, open forests, cliffs, talus R- forests 40+ yr old <sup>2</sup> and in 80+ yr old forests <sup>1</sup>

## APPENDIX A: SPECIES DESCRIPTIONS AND SURVEYS

2	Northern saw-whet owl	17-20 <sup>1,4,24</sup>		12 <sup>2</sup>	15-20 <sup>1,2</sup>		most forest types with dense closed canopy forests F/R- in forests 40+ yr old <sup>2</sup> and 80+ yr old forests <sup>1</sup>
2	Northern flicker	17-21 <sup>1,16,24,29,33</sup> , 24-27 <sup>7,8,12</sup>	30-72 <sup>8,9,10,12,20,33</sup>	12 <sup>2</sup>	10 <sup>1,2</sup>	0.4-0.5 <sup>1,2,40</sup> 1.2 <sup>44</sup>	excavates cavities in soft snags, found in all forest types conifer/mixed, open areas F- wetlands, adjacent to water, forests - all ages R- mixed/conifer 40+ yr old forests <sup>2</sup> and 80+ yr old forests <sup>1</sup>
3	Pileated woodpecker	20-25 <sup>1,8</sup> , 30-34 <sup>2,4,6,7,8,9,10,33</sup>	31-65 <sup>20</sup> , 91-130 <sup>6,8,9,10,31,33</sup>	20 <sup>2</sup>	31-40 <sup>1,2</sup>	0.06 <sup>1</sup> 0.14 <sup>2,45</sup> 0.45 <sup>44</sup> 3.2 <sup>43</sup>	excavates cavities in hard/soft snags/trees, found in mature or older conifer/mixed forests, open areas with large logs F- large snags/trees/logs/stumps in 80+ yr old <sup>1,2</sup> , forages in younger clearcuts with logging debris forests, clearcuts with abundant logs R- large snags/trees in 80+ yr old forests <sup>1,2</sup>
3	Wood duck	25 <sup>1</sup>		12 <sup>2</sup>	6-10 <sup>1,2</sup>		within 200 feet of wetlands, deciduous/mixed forests in or adjacent to low gradient rivers, sloughs, lakes, ponds, wetlands F- wetlands, open water, riparian, grasslands to old-growth forests R- 80+ yr old <sup>1,2</sup> riparian forests, utilizes nest boxes
3	Common merganser	25 <sup>1</sup>		15 <sup>2</sup>	6-10 <sup>1,2</sup>		within 200 feet of wetlands, 80+ yr old forests <sup>1,2</sup> in or adjacent to low gradient rivers, sloughs, lakes, ponds, wetlands F- wetlands, open water, riparian, grasslands to old-growth forests R- 80+ yr old <sup>1,2</sup> riparian forests, utilizes nest boxes

(a) size classes (inches dbh) 1= 8.0 -14.0 inches dbh; 2=14.1-20.0 inches; 3=>20.0-inches

(b) min=minimum size based on literature review species will use; ave=average size based on literature review species selects, typical size of tree or snag used

(c) Old-age forests are defined as greater than 100 years old, and old-growth forests are defined as greater than 120 years old

References for size classes: and location of study:

(1) Brown 1985 [W WA/OR]; (2) Thomas et al. 1979 [NE OR]; (4) Scott et al. 1980 [Western US]; (6) Lundquist and Mariani 1991 [Southern WA Cascades]; (7) Mannan et al. 1980 [W OR]; (8) Madsen 1985 [NE WA - Okan.]; (9) McClelland 1977 [N Rocky Mnts]; (10) Bull 1980 [NE OR]; (12) Raphael and White 1984 [Sierra Nev - CA]; (16) Zarnowitz and Manuwal 1985 [NW WA]; (17) Cunningham et al. 1980 [Rock Mnts]; (20) Morrison et al. 1983 [WA/OR]; (24) McClelland et al. 1979 [E WA?]; (29) Gutzwiller and Anderson 1987 [WY]; (33) Bevis 1994 [Central WA Cas]; (39) Robert 1966 [?]; (40) Pugh and Pugh 1957 [CA]; (41) Beaver 1972 [CA]; (42) Akers 1957 [Pac NW]; (43) Bull and Holthausen 1993 [NE OR]; (44) Thomas et al. 1976 [NE OR]; (45) Bull and Meslow 1977 [NE OR]; (46) Roest 1957 [US- general]; (47) Brewer 1961 [US- general]; (48) Schroeder 1983a [US- general]; (49) Garrison 1988 [US- general]; (50) Sousa 1987 [US- general]; (51) Schroeder 1983b [US- general]

## Appendix B: Riparian Guidelines

### Riparian Strategies

Eight riparian strategies were defined by identifying the functional needs of groups of closely related channel classes and the dominant interactions of each channel class groups with their riparian forest (Table 25). It is the intent of Simpson's riparian strategies to meet the functional needs and provide for the dominant riparian forest interactions of each channel class by: (1) specifying a point of measurement and minimum and average widths (Table 26); (2) designating management guidelines for the RCR (Table 27); and (3) specifying guidance for harvest unit layout adjacent to streams through narrative descriptions of each riparian strategy. These narrative descriptions pertain to the functional characteristics of groups of channel classes and integrate information about the plant potential of riparian settings and natural disturbances likely to occur in those settings. By including the narratives, Simpson intends to provide information for its foresters to consider in the course of harvest unit layout to provide the maximum level of riparian protection within the specified quantitative boundaries outlined in the prescriptions (i.e., Tables 28 and 29). Specifically, the narratives are included to provide insight into how variable width buffers might be designed to optimize ecological function and obtain maximum environmental benefits within the described boundary limitations.

#### *Canyon*

The primary management function of the *Canyon* riparian strategy is the provision of LWD from off site, and maintenance of on site shade and detrital inputs. The purpose of this strategy is to maintain the sediment and organic matter storage capacity of the upper channel network, keep convective heat transfer to a minimum and supply detritus to the channel as its principle energy source. This strategy will be applied in the Crescent Uplands (CUP) LTU unit along the highly confined channel network of the Olympic foothills. No current harvest is taking place in these stands (most were logged for the first time only in the 50's and 60's) and no streamside trees were retained at that time.

The retention of sediment behind debris dams, in otherwise sediment limited channel reaches, is the dominant physical process Simpson will be managing. If this capacity is reduced by the break up of storage structures (LWD dams), the sediment will be carried to downstream reaches where it accumulates in flatter channel segments (ROP-C7) along the foothills front boundary. Salmon and trout habitat is thus compromised by the filling of pools and loss of surface flow in the summer. There may be some opportunity for management of these riparian leave areas but the plantations are still young and terrain would require cable thinning or helicopter operations. Leave areas will not be uniform in width, but concentrated in areas that have a high probability of contributing LWD to the channel network. Leave areas will also be fashioned to maintain refugia for stream breeding amphibians.

#### *Channel Migration*

The primary management function of the *Channel Migration* riparian strategy is the retention of sediment and organic matter and maintenance of nutrient processing. Numerous other riparian forest functions will be provided by default through this strategy including, bank stability and the growth of very large specimen cedar and spruce for ultimate contribution of LWD. The purpose of this strategy is to maintain the floodplain processes that contribute to nutrient processing

within the soil and the hyporheic<sup>22</sup> zone and ensure continued development of topographic complexity of floodplain surfaces. The *Channel Migration* riparian strategy is being applied to two settings; either very large meandering alluvial channels inset within well defined terrace systems or those low gradient smaller channels with highly erodible banks, (e.g. AGL-Qa6, CIS-Qc3, or SIG-M6 channel segments in the Alpine Glacial, Crescent Islands, and Sedimentary Inner Gorges LTUs respectively).

This strategy recognizes flood flow bank erosion, including uncommon but inevitable channel avulsions as the principal disturbance agent for these channel types and their riparian forests. Cutting boundaries Table 26 and Table 27) guarantee that when channel avulsions occur, suitable riparian forest corridors will be adjacent to the new channel. The expected result due to implementation of this strategy is the continued development of floodplain complexity and micro-topography including the many types of small channels that are important for overwintering habitat of salmonids, especially coho salmon.

#### *Temperature Sensitive*

The primary management function of the *Temperature Sensitive* riparian strategy is shade and the control of streamside air temperature. The purpose of this strategy is the mediation of water temperatures in channels that are vulnerable to summer time increases. This strategy is being proposed for channel class ROP-Qc3. Temperature is an issue elsewhere as well but this is an especially important channel class in terms of fish utilization and miles. Cutting boundaries should be established that provide the greatest shade from the mid-day to the early afternoon. This may result in a wider, denser leave area on south and west aspects. All of these channels have very low summer flows and ample supplies of gravel which frequently form broad riffles over which the water flows in thin layers exposing it to conductive heat transfer. Maintenance of adequate shade over these streams will provide a better rearing environment for coho, cutthroat, and steelhead.

#### *Inner Gorge*

The primary management function of the *Inner Gorge* riparian strategy is the provision of LWD from unstable slopes. The purpose of this strategy is to provide wood large enough to maintain position or lodge in channel classes like SIG-L4, SIG-M5, AGL-Qo8, and AGL-Qa6 channels. Although function of LWD changes in channels of this size and the architecture of LWD accumulations is different, it is nonetheless very important to the development of productive main river habitat. Trees in second growth forests today are just approaching a size that produces functional LWD in large channels. It would be desirable for them to attain additional size before they are recruited to the main rivers. To accomplish this the timber harvest boundary is set back from directly delivering inner gorge side slopes. Floodplain complexity will be enhanced by this strategy over the long run. Maintenance or creation of this kind of habitat is important in these channels due to their relatively confined character. Growing big wood fast is the goal of this strategy. Within this strategy there should be significant opportunity for active management. However, in these areas the largest trees that have the highest likelihood of recruiting to the river must be retained.

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<sup>22</sup> The hyporheic zone consists of subsurface gravels and interstitial waters which mix with surface and groundwater. Recent research has shown that important biological and chemical processes occur in the hyporheic zone that contribute to the productivity of surface waters.

### *Alluvial Bedrock Transition*

The primary management function of the *Alluvial Bedrock Transition* riparian strategy is the provision of LWD. The purpose of this strategy is the maintenance of an alluvial channel bed in channel classes likely to scour to bedrock in the absence of LWD. (A minimum diameter of about 0.8 m is needed before LWD is functional in these channels). This strategy will be applied along channel classes SIG-M3 and SIG-M4 channels. The principal recruitment zone for high value LWD is at and just beyond the break in slope.

Valley walls of these channel types are overlain with a thin mantle of soil which is quite unstable. The valley walls may never have produced many large conifer making it especially important to produce them on surfaces that are stable long enough to recruit trees of large size and where they will be delivered to the stream. Unless a supply of LWD is provided to these streams over time they will lose their alluvial character because they have no connection to upland channel networks where weathering bedrock and mass wasting contribute a continual flow of colluvium for fluvial processing. The focus of stand manipulation in this strategy is to grow big conifers fast, requiring considerable silvicultural intervention since many stands adjacent to these channels are dense western hemlock. Sitka spruce grows rapidly in these settings and care should be taken to release younger individuals in the understory.

### *Break in Slope*

The primary management function of the *Break in Slope* riparian strategy is the provision of LWD. A wide range of channel classes are assigned this strategy (Table 25). Cutting boundaries should be moved back away from the break in slope with emphasis being given to wind and shade protection of south and west aspects. As with the *Alluvial Bedrock Transition* riparian strategy, the boundary needs to be back because the inner side slopes adjacent to the channel are not the surfaces from which conifer LWD is recruited.

In the AGL, the cemented gravels of the side slope are overlain with thin soils and the boundary horizon accumulates water. Alder, salmonberry, and devils club predominate on those slopes. The smaller of these channels dry up in the summer but are used by juvenile steelhead for winter refuge. Without LWD the pools needed for winter resting are not maintained as the channel reverts to plane bed morphology. In the larger channels the same pools are needed for the maintenance of older year classes of cutthroat trout and coho throughout the year. This strategy provides ample opportunity for active management as the surfaces above the break in slope are suitable for ground based logging systems.

### *Reverse Break in Slope*

Primary management functions targeted by the *Reverse Break in Slope* strategy are the provision of LWD and nurse logs. The purpose of providing nurse logs is to maintain conifer germination sites in an otherwise unfavorable environment. LWD is needed for creating channel complexity. This strategy is being proposed adjacent to channel classes SIG-L2 and AGL-Qo4 (Table 25). The proposed cutting boundaries for these sites should retain a conifer component for establishment of large trees for eventual recruitment of LWD to the channel and the forest floor. These settings are typified by wet understory plant communities whose early seral stages are dominated by red alder. After the first logging, these sites reverted to alder and today present one of the most difficult riparian recovery challenges.

Channels traversing these valleys are low to moderate gradient and provide potentially very good fish habitat. Most of the wood left in these channels today is residual old growth and is in advanced stages of decay. Without new wood recruitment over the next several decades to direct the erosive energy of the streams in forming new pools, pool spacing will go up with commensurate loss of habitat for older year classes of trout. Red alder stands adjacent to these channels are at their peak of vigor now and will be declining over the next thirty years. The few scattered conifer saplings that can be found in the understory are currently suppressed but represent a valuable resource for the future. All conifers should be maintained in the understory and a conifer component should be retained in the outermost riparian boundary.

#### *Unstable Slopes/Intermittent Flow*

The purpose of the *Intermittent Flow* riparian strategy is to maintain important functional linkages between channel segments and their riparian areas for channel classes that typically have low average fish resource value. However, this strategy explicitly recognizes that physical processes may transmit significant impacts from these channel classes, downstream to other channel segments of the same class or those of other classes that are longitudinally connected, and for which on-site biological resource value is high. This group of channel classes is highly diverse, lies at the tip of the channel network in all LTUs, and constitutes the smallest of channels but the preponderance of the total actual channel mileage. In the majority of cases, segments of these channel classes will not support fish, but within a class, there is substantial variance with respect to physical condition and the presence of particular species.

Where any species of fish are present, a 20 meter average (3 acres per 1,000 feet), no harvest, continuous buffer outside the channel disturbance zone will be retained in a pattern that optimizes functional needs for specific channel classes. See Appendix E for more details about functional characteristics of specific channel classes. Unstable slopes adjacent to these channel classes will also be afforded continuous protection.

Where no fish are present and no instability exists, 80 trees per 1,000 feet of channel shall be retained that are representative of the pre-harvest stand size distribution and species composition. In these cases, leave trees should be clumped in patches designed to optimize the functional needs for specific channel classes. The clumping of leave trees along non-fish bearing portions of these channel classes will provide discontinuous forest fragments for recruitment of LWD and immediate protection for stream breeding amphibians in the perennial segments. The majority of segments afforded this strategy will be intermittent.

Table 25. Key to channel classification scheme and its relation to riparian strategies.

Channel Classifiers							
Channel Width (CW)		Confinement by Valley Width (VW) to CW Ratio			Channel Bed Morphology		
Small = 0 - 4 m Medium = 4 - 16 m Large = > 16 m		Highly confined = $VW < 2 \times CW$ Moderately confined = $VW 2 - 4 \times CW$ Unconfined = $VW > 4 \times CW$			Bedrock = BD Cascade = Cas Step-pool = SP Forced step pool = SP <sub>f</sub> Plane-bed = PB Forced pool riffle = PR <sub>f</sub> Pool riffle = PR Braided = BR		

Lithotopo Unit				
Crescent Uplands (CUP)	Recessional Outwash Plain (ROP)	Crescent Islands (CIS)	Sedimentary Inner Gorges (SIG)	Alpine Glacial (AGL)
CUP-C1 = Sm, HC, Cas/BD CUP-C2 = Sm, HC, SP/Cas CUP-C3 = Sm, HC, SP <sub>f</sub> /SP CUP-C4 = Md, HC, SP/BD CUP-C5 = Md, MC, SP <sub>f</sub> /PB CUP-C6 = Md, HC, SP/PB CUP-C8 = Lg, HC, SP/PB	ROP-C7 = Md, UC, BR/PB/PR <sub>f</sub> ROP-Qa7 = Lg, UC, BR ROP-Qc1 = Sm, UC, PR <sub>f</sub> ROP-Qc2 = Sm, HC, PR <sub>f</sub> /SP <sub>f</sub> ROP-Qc3 = Md, UC, PR <sub>f</sub> /PR ROP-Qc4 = Md, HC, PB/PR <sub>f</sub> ROP-Qc5 = Md, HC, PB/PR <sub>f</sub> ROP-Qc6 = Md, UC, PR ROP-Qc7 = Lg, MC, PR/BR ROP-Qc8 = Lg, MC, PR/PB	CIS-C1 = Sm, HC, SP <sub>f</sub> CIS-C5 = Md, MC-UC, PR <sub>f</sub> /PB CIS-Qc1 = Sm, HC, SP <sub>f</sub> CIS-Qc2 = Sm, MC-UC, PR <sub>f</sub> CIS-Qc3 = Md, UC, PR <sub>f</sub> /PR	SIG-L1 = Sm, HC, SP <sub>f</sub> SIG-L2 = Sm, MC, PR <sub>f</sub> /PR SIG-L3 = Md, HC, SP <sub>f</sub> /BD SIG-L4 = Lg, HC, PR/PB SIG-M1 = Sm, HC, SP <sub>f</sub> SIG-M2 = Sm, MC, PR <sub>f</sub> SIG-M3 = Md, HC, BD /PR <sub>f</sub> SIG-M4 = Md, MC, BD/PR <sub>f</sub> SIG-M5 = Lg, HC, PR/PB SIG-M6 = Md, UC, PR SIG-Qa6 = Lg, UC, PR SIG-Qc1 = Sm, HC, SP <sub>f</sub> SIG-Qc2 = Sm, MC-UC, PR <sub>f</sub> SIG-Qc3 = Md, MC-UC, PR <sub>f</sub> SIG-Qo1 = Sm, HC, SP <sub>f</sub> /SP SIG-Qo2 = Sm, MC-UC, PR <sub>f</sub> SIG-Qo3 = Md, HC, PR <sub>f</sub> /SP <sub>f</sub> SIG-Qo4 = Md, MC, PR <sub>f</sub> /PB	AGL-Qa6 = Lg, UC, PR AGL-Qo1 = Sm, HC, SP <sub>f</sub> /SP AGL-Qo2 = Sm, MC-UC, PR <sub>f</sub> AGL-Qo3 = Sm, HC, PR <sub>f</sub> /SP <sub>f</sub> AGL-Qo4 = Md, UC, PR <sub>f</sub> /PB AGL-Qo5 = Md, HC, PR <sub>f</sub> AGL-Qo6 = Md, HC-MC, PR <sub>f</sub> /PB AGL-Qo7 = Lg, HC, PR/PB AGL-Qo8 = Lg, HC, SP/PB

Riparian Strategies							
Canyon	Channel Migration	Break in Slope	Inner Gorge	Unstable and Intermittent	Reverse Break in Slope	Temperature Sensitive	Alluvial Bedrock Transition

**Table 26. Riparian management area widths and associated guidelines by channel class.**  
Narrative objectives for each riparian strategy are provided in preceding text.

Channel Class	Miles	Avg. Width <sup>23</sup>	Min. Width	Measure d From	Riparian Strategy	Guide	Type locale Stream and GIS Segment No.
AGL-Qa6	12.7	40/30	25	CMZ	Channel migration	3	Wynoochee; 11/20/8; 25262
AGL-Qo1	61.3	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 6/20/7; 26100
AGL-Qo2	22.5	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 29/21/7; 42518
AGL-Qo3	7.3	25/15	10	BIS	Break in slope	2	Unnamed; 14/20/8; 24979
AGL-Qo4	2.6	30/20	20	CDZ	Reverse break in slope	3	Unnamed; 35/21/8; 26812
AGL-Qo5	8.8	20/10	5	BIS	Break in slope	2	Unnamed; 14/20/8; 24831
AGL-Qo6	13.6	30/20	10	BIS	Break in slope	2	Schafer; 32/21/7; 26659
AGL-Qo7	3.7	30/20	10	BIS	Break in slope	2	Schafer; 24/20/8; 23838
AGL-Qo8	5.2	30	20	BIS	Inner gorge	2	Wynoochee; 12/21/8; 30865
CIS-C1	83.9	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 15/19/4; 17265
CIS-C5	1.7	40/30	20	CDZ	Reverse break in slope	3	Rock; 23/19/5; 16046
CIS-Qc1	33.3	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 16/19/4; 17055
CIS-Qc2	28.0	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 16/19/4; 17350
CIS-Qc3	16.8	30/25	20	CMZ	Channel migration	3	Kennedy; 31/19/3; 12238
CUP-C1	199.9	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 24/21/6; 2900
CUP-C2	22.9	25	15	CDZ	Canyon	1	Unnamed; 17/21/5; 29607
CUP-C3	24.5	25	15	CDZ	Canyon	1	Unnamed; 17/21/5; 29535
CUP-C4	4.9	25	15	CDZ	Canyon	1	N. Mtn.; 17/21/5; 29241
CUP-C5	3.5	25	15	CMZ	Canyon	3	Dry Bed; 13/21/6; 29150
CUP-C6	3.6	30	20	CDZ	Canyon	1	Baker; 16/21/6; 30414
CUP-C8	5.9	35	25	BIS	Inner gorge	2	M Fk Satsop; 16/21/6; 29741
ROP-C7	9.4	40/40	20	OHW	Channel migration	3	N Mtn; 21/21/5; 27963
ROP-Qa7	3.7	50/40	30	CMZ	Channel migration	3	Vance; 10/21/5; 31355
ROP-Qc1	167.3	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 28/20/5; 22360
ROP-Qc2	103.4	3/1	0	BIS	Break in slope	2	Unnamed; 29/20/5; 22697
ROP-Qc3	44.2	30/25	20	CMZ	Temperature sensitive	3	Glenn; 33/20/5; 21864
ROP-Qc4	9.1	20/15	10	BIS	Break in slope	2	Unnamed; 31/21/5; 26917
ROP-Qc5	12.1	30/20	15	BIS	Break in slope	2	Bingham; 36/20/6; 21088
ROP-Qc6	9.5	40/30	20	BIS	Channel migration	2	Decker; 31/20/6; 21845
ROP-Qc7	15.2	65/40	30	CMZ	Channel migration	3	Stillwater; 32/20/5; 20675
ROP-Qc8	2.8	40	30	BIS	Channel migration	3	E. Fk. Satsop; 21/19/6; 16167
SIG-L1	160.0	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 23/21/7; 29219
SIG-L2	38.5	30/20	20	CDZ	Reverse break in slope	1	Unnamed; 34/19/6; 12478
SIG-L3	6.3	20/15	10	BIS	Break in slope	2	Unnamed; 24/21/7; 28809
SIG-L4	24.2	40 <sup>24</sup>	25	BIS	Inner gorge	2	W. Fk. Satsop; 34/21/7; 26789
SIG-M1	67.8	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 3/18/6; 11250
SIG-M2	18.5	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 32/20/7; 21375
SIG-M3	9.6	30/15	10	BIS	Alluvial/bedrock	2	Unnamed; 3/20/7; 26221
SIG-M4	6.0	40/25	20	BIS	Alluvial/bedrock	2	Sandstone; 9/20/7; 25521
SIG-M5	15.1	40	25	BIS	Inner gorge	2	Canyon; 10/20/7; 24873
SIG-M6	2.3	50/30	30	CMZ	Channel migration	3	Cook; 4/18/6; 11122
SIG-Qa6	11.3	40	25	CMZ	Channel migration	3	W. Fk. Satsop; 33/20/7; 21687
SIG-Qc1	12.8	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 22/20/7; 23769
SIG-Qc2	8.9	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 13/20/7; 24502
SIG-Qc3	9.1	25/15	10	CMZ	Temperature sensitive	3	Unnamed; 22/20/7; 23132
SIG-Qo1	38.3	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	N. Fk. Abyss; 28/21/7; 27524
SIG-Qo2	19.0	3 ac/Mft.	20/10	CDZ	Unstable / Intermittent	4	Unnamed; 29/20/7; 22670
SIG-Qo3	4.8	25/15	10	BIS	Break in slope	2	Unnamed; 16/20/7; 42409
SIG-Qo4	2.0	30	20	BIS	Break in slope	2	Devils Club; 16/21/7; 29638
<b>Total</b>	<b>1397.8</b>						

<sup>23</sup> All widths are in meters; where two average widths are given, the wider applies to the windward aspect and the lesser to the leeward aspect, in cases where only one average width is provided, it applies to both sides of the stream. In the case of the Unstable/Intermittent Flow strategy some segments will be given discontinuous buffers consistent with Guideline 4, Table 27.

<sup>24</sup> Except when a stable terrace exists below inner gorge slope, then harvest permitted to break in slope.

Table 27. Riparian management guideline descriptions

Guideline	Description
1	No-harvest
2	No-harvest in CMZ and to the break in slope. If conifer basal area in the managed zone exceeds 150 square feet per acre <sup>25</sup> , 40% of the trees may be harvested subject to the following limitations: 1) on the windward side of the stream, harvest will be from the lower end of the size distribution, in no case will dominant trees be taken nor density reduced below 25 tpa, and 2) on the leeward side of the stream, harvest operations shall not appreciably alter the DBH size distribution or species composition from the pre-existing stands.
3	No-harvest in CMZ or CDZ and first 10 m upslope. If conifer basal area in the managed zone exceeds 150 square feet per acre <sup>19</sup> , 40% of the trees may be harvested subject to the following limitations: 1) on the windward side of the stream, harvest will be from the lower end of the size distribution, in no case will dominant trees be taken nor density reduced below 25 tpa, and 2) on the leeward side of the stream, harvest operations shall not appreciably alter the DBH size distribution or species composition from the pre-existing stands.
4	Applies to small channel classes: (some segments within virtually all of the classes will have fish and/or unstable side slopes).  A. Where fish <sup>26</sup> are present: retain a minimum 3.0 acres of no-harvest leave area per 1,000 feet of channel beyond the channel disturbance zone. A 10 and 20 meter minimum width extending from the channel disturbance zone will be preserved on the leeward and the

<sup>25</sup> Basal area will be averaged for each side of the stream by individual timber harvest units. Thinning in some areas that exceed 150 square feet per acre conifer basal area is a management prescription that should achieve two goals: (1) promote rapid growth of the remaining stand by reducing its relative density; and (2) provide an opportunity for Simpson to recover commodity value at a low risk to the riparian environment. Simpson estimates that approximately 6,400 acres (22% or the total RCR) may be available for this treatment (see Section 6.2.1.1). The areas where this management prescription generally applies have a lower than average likelihood of contributing woody debris to channels. The riparian forest function provided in these areas are buffering for windthrow protection and protection of the inner core of the riparian reserve. Those surfaces which have the highest likelihood of contributing functionally to channels have received full no-harvest protection.

<sup>26</sup> Fish are defined as all fish including sculpins and lamprey (see Table 1). Simpson will determine the presence or absence of fish with the use of electro-fishing gear. While “habitat diagnostics” approaches are currently popular, Simpson has extensive experience with fish distribution and habitat characteristics in the Plan Area and knows that the habitat based approaches often understate or overstate the actual zone of fish use. Unless an abrupt and permanent change in physical characteristics occurs Simpson seldom documents the end of fish distribution as the last fish in its surveys because it believes this point may move upstream or downstream over time, depending on small scale changes to habitat or inter-annual variation in flows. There is most often a tributary junction nearby in the upstream direction that makes a reasonable breaking point. Often these confluence represent points in the channel network where watershed area is reduced by such a significant amount (sometimes by half) that the channel characteristics change significantly. These changes usually render the channel incapable of supporting fish due to a shift to “colluvial” conditions. Simpson does its fish distribution surveys at times that optimize the opportunity of finding fish based on life history traits and seasonal movement patterns.

	<p>windward sides of the stream respectively. The balance of the leave area shall be organized to protect and develop a full range of riparian forest functions as they occur for specific channel classes and individual stream settings. It is anticipated that the leave acreage outside the minimum zones will be concentrated on the windward side, around tributary junctions, forested wetlands, side slope seeps, adjacent to reaches where discontinuous terraces may occur or develop, and in areas that may be especially prone to windthrow. Any unstable slopes that lie streamward of a 20 m average boundary on each side (from the CDZ) may be counted toward the 3.0 acre leave requirement but leave areas buffering unstable slopes outside that zone, are additive and guided by prescriptions in Section 5.2.4.</p> <p><b>B.</b> Channel segments that support fish at any time of the year, but that are seasonally or temporally intermittent shall be provided continuous buffer protection consistent with other provisions of this guideline 4.</p> <p><b>C.</b> Unstable slopes adjacent to the channel will not be harvested and shall be afforded continuous no harvest protection.</p> <p><b>D.</b> In the remaining segments not receiving continuous protection under conditions in <b>A - C</b> above, 80 trees per 1,000 feet of channel shall be retained (equal in size distribution and species characteristics to the pre-harvest stand). The leave trees shall be left in at least 0.5 acre patches (however credit will be given for isolated trees) that will be organized to provide functional requirements for specific channel classes.</p> <p><b>E.</b> Where delivering unstable side slopes exist adjacent to channel segments given the 80 trees (0.5 acres) per 1,000 feet guideline and where such segments lie sequentially upstream from fish bearing segments, leave will be increased to 160 trees (1.0 acres) per 1,000 feet and will be left in a continuous buffer immediately adjacent to the channel.</p>
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## **Appendix C: Details of Road Inventory**

### **General**

Simpson will implement a comprehensive and systematic inventory of its entire road system as part of the HCP implementation (Section 5.2.2.1(b)). The purpose of this inventory is to identify problems with the road system that need to be corrected in order to prevent harm to public resources. These problems will be prioritized and scheduled for remedial work using information collected during the inventory. Data collected during this inventory will be organized and stored in a database associated with Simpson's GIS (Section 5.2.2.1(c)). For those problems that require follow-up actions or inspections, the inventory and the database will be used to establish schedules and produce automatic work orders for the road maintenance crews.

The inventory will be implemented on a priority basis for watersheds ranging in size from 2,000-10,000 acres. Watershed priorities will be established based on the value of aquatic resources potentially at risk. Highest priority will be accorded watersheds currently supporting large numbers of anadromous salmonids (e.g. Kennedy, Bingham, and Schafer Creeks). Simpson will establish these priorities in consultation with the SAT.

What follows is a brief description of the inventory procedure and the outputs from the database.

### **Road Inventory Procedure**

The road inventory will be implemented at a small watershed scale (2,000-10,000 acres) in an order that will be based on their significance to anadromous salmonid production. The SAT will be consulted during the development of a priority list for implementation of the road inventory. The actual inventory process will consist of three primary stages; 1) office planning, 2) field inspection and data collection, and 3) data entry and report generation. All three work categories for individual road inventories will be the responsibility of the same individual.

#### *Office Planning*

In this stage of the inventory two primary tasks are to be completed; 1) a review of the historical performance of the road system, and 2) logistical planning. Sequential aerial photos will be reviewed to document past failures within the road system being inventoried. These sites will be transferred onto the maps that are assembled at this point for reference and special attention during the field inspection stage of the inventory work. A compilation of notes assembled during this phase will become a permanent part of the archived record for each road inventory.

#### *Field Inspection and Data Collection*

A visual inspection of the entire road system will be made. During these inspections, a data sheet will be filled out for each road segment (defined by road junctions) and each channel intersection that occurs in that segment (see accompanying example data sheets). Inspection work will be completed by Simpson personnel who have many years of experience identifying maintenance requirements for logging roads. During this inspection the road system will be evaluated for the likelihood of its impacts to public resources by inspecting a complete range of structural features and assessing how they are functioning and interacting with natural landscape characteristics.

Field inspections are separated into two separate data categories; 1) the road (including the running surface, ditches, relief culverts, cutbanks and sidecast), and 2) channel crossings.

1. Evaluation of all road-related sediment delivery mechanisms.

All road segments will be evaluated for problems in the following areas:

- a) Ditch erosion and incision.
- b) Adequacy of road drainage features including road prism grading, relief culvert spacing, and relief culvert outfall location and treatment.
- c) Stability and potential deliverability of sidecast material.
- d) Cut slope stability and relationship to ditch function.
- e) Interception of shallow subsurface flow.
- f) Drainage piracy and transfer of water between catchments.

2. Evaluation of all channel and road intersections.

All channel and road intersections will be evaluated for problems in the following areas:

- a) Fish passage at all culverts.
- b) Flood flow capacity of the culvert.
- c) Road surface sedimentation from approaches.
- d) Likelihood of diversion at the culvert.
- e) Likelihood of fill failure and approximate volume that could be lost.
- f) Structural condition of culvert.

### **Road Segment Database**

#### *Road Inventory Data Entry and Report Generation*

The data collected in the field (as described) will be entered into Simpson's Road Segment Database. Data will be stored in the database for roads as well as for all channel crossings. This information will then tie directly to our GIS system so that maps and other GIS overlays can be created.

The database and GIS system will be used to generate reports and maps showing, for example, an average road score per mile and an average score per crossing for each basin. Based on the sensitivity of each basin (biological and water quality needs), and the field data, reports will be generated to help prioritize maintenance work. For the highest priority basins, detailed work orders will be developed and entered into the database that will best address the causes of the problems in that area to reduce the risk of future sediment delivery. The database will also be

used by the road crew to schedule work and to account for work completed. Annual compliance reports and maps will be created from this database and GIS system to show where and how much work was completed.

*Database Outputs*

1. Identification of road segment status.

The plan area has roads of different ages and construction standards, many of which were built without a comprehensive view of long term logging or maintenance plans. Consequently there has not been any systematic evaluation of the need for many miles of existing road, much of which is currently in an inactive haul status. All road segments will be assigned an activity status in the inventory causing Simpson to determine if roads are needed for long term forestry operations. This action will place many road segments into a category for candidate decommissioning. Roads deemed non-essential for long term forestry operations will be candidates for decommissioning or dormancy conditioning.

2. Identification of problems associated with specific road segments and channel crossings.
3. Prioritized work orders for the maintenance crews.
4. Tracking system for recurrent inspection and maintenance requirements.

DRAFT Road/Stream Crossing Inventory/Maintenance Data Sheet

Road #: \_\_\_\_\_ Road\_Point\_ID #: \_\_\_\_\_ Road\_Pnt\_Mslink #: \_\_\_\_\_

Date Inv: \_\_\_\_\_ Inspector: \_\_\_\_\_

Comments: \_\_\_\_\_  
\_\_\_\_\_

Work Orders: \_\_\_\_\_  
\_\_\_\_\_

Re-inspection Schedule:    Annual            2 years            5 years            10 years

Crossing Type:            Bridge            Culvert

**Bridges:**

Year Installed: \_\_\_\_\_

	Problem:	Ranking:	Comments:
Inadequate High Flow Protection?	Yes / No	_____	
Direct Delivery from Approach?	Yes / No	_____	
Direct Delivery from Ditchline?	Yes / No	_____	

**Total Bridge Ranking Score:** \_\_\_\_\_/9

**Culverts:**

	Problem:	Ranking:	Comments:
Functional/Flow problems?	Yes / No	_____	
Inadequate High Flow Protection?	Yes / No	_____	
Direct Delivery from Approach?	Yes / No	_____	
Direct Delivery from Ditchline?	Yes / No	_____	
Filled in catch basins?	Yes / No	_____	
Fish Blockage?	Yes / No	_____	
Failure Risk?	Yes / No	_____	
Estimated fill volume (cubic yards)		_____	

**Total Culvert Ranking Score:** \_\_\_\_\_/21

Priority Ranking Scoring:    3 - High Priority  
                                      2 - Medium Priority  
                                      1 - Low Priority  
                                      0 - No Mitigation Needed

**DRAFT Road Segment Inventory/Maintenance Data Sheet**

Road #: \_\_\_\_\_ **Road\_Inv\_ID #:** \_\_\_\_\_ Segment #'s: \_\_\_\_\_

Date Inv: \_\_\_\_\_ Inspector: \_\_\_\_\_

Comments: \_\_\_\_\_

Work Orders: \_\_\_\_\_

**Road\_Type:** Mainline Branch Spur Railroad Other

**Current Road Activity Status:** Active Inactive Blocked Orphaned Deactivated

**Future Road Use Category:** Permanent Dormant Decommission

**Re-inspection Schedule:** Annual 2 years 5 years 10 years

<b>Cut Slope</b>	Excessive Raveling/Eroding?	Problem: Yes / No	Ranking: _____	Comments:
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<b>Ditches</b>	Excessive Ditch Erosion?	Yes / No	_____
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<b>Surfacing</b>	Eroding and delivering?	Yes / No	_____
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<b>Cross-Drains</b>	Inadequet Size/Spacing?	Yes / No	_____
	Needs Energy Dissipators?	Yes / No	_____
	Filled in catch basins?	Yes / No	_____

<b>Sidecast</b>	Unstable/cracking?	Yes / No	_____
	Excessive Ravelling/Eroding?	Yes / No	_____

<b>Brush</b>	Is brush control needed?	Yes / No
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**Total Ranking Score:** \_\_\_\_\_/18

Priority Ranking Scoring: 3 - High Priority  
 2 - Medium Priority  
 1 - Low Priority  
 0 - No Mitigation Needed

### Definitions – Road Terms

#### Road Types (to be mapped in GIS roadcl.dgn layer):

**Mainline:** Forest road that is of highest standard and has high traffic levels, used frequently for hauling forest products, usually road # ends with 00. These roads will be part of our permanent road system.

**Branch:** System road connecting spurs to mainline, used for multiple units over time, not as much traffic compared to mainlines, usually road # ends in 10's or 5's. These roads may be a part of our permanent road system.

**Spur:** Short, lower standard forest road used for a particular forest practice. Needed for logging, planting, and continuing management of unit, but traffic levels are lower still than branch roads. These roads may be deactivated after use.

#### Current Road Activity Status:

**Active Roads:** Forest roads actively used for hauling forest products (wood, rock, etc). Must maintain culverts and ditches, minimize erosion of road surface, and crown, outslope or waterbar.

**Inactive Roads:** Forest roads where hauling has been discontinued for 1 or more seasons. Must clear culverts and ditches before 1<sup>st</sup> rainy season and crown, outslope or waterbar. Then landowner is not liable for penalties.

**Blocked:** Roads that have been tank-trapped or otherwise blocked to vehicle access, but with little or no deactivation work done.

**Orphaned:** Old forest roads that are inactive and haven't been used for years. These roads may or may not be driveable.

**Deactivated:** 2 classes of deactivated roads: decommissioned and dormant. (see definitions below)

#### Future Road Use Categories:

**Permanent Roads:** forest roads needed permanently for long-term forest management.

**Dormant Roads:** Roads put into a dormant category such that the chances of erosion and failure are virtually eliminated. Examples of dormancy work include blocking vehicle access, pulling back unstable sidecast near stream crossings, clearing ditches, culverts opened or culvert and fill removed, road surface outsloped or crowned, cross ditches or other drainage structures added.

**Decommissioned Roads:** Roads to be decommissioned such that hill slope function and drainage patterns will be returned to a natural state and the road prism will be virtually eliminated and revegetated. Examples of decommissioning work include blocking access, pulling back sidecast, outslope and obliterate road prism, fills at all crossings removed and culverts or bridges pulled, cross ditches or other drainage structures added, and exposed surfaces revegetated.

Road Maintenance:

**Operational:** Continuing work done on active roads to keep them up to standards during use, including grading, crowning, ditch clean out, etc.

**Emergency:** Emergency work done to repair recently created major problems (slides, etc.), that is done rapidly to keep roads open. A post event analysis will be done to identify factors involved in causing the damage and to determine if other additional steps need to be taken to prevent such future occurrences.

**Preventative (Inventory):** Future road maintenance and deactivation work done in compliance with HCP that will be determined from field inventory and prioritization work.

Drainage Structures:

**Cross Drain:** Culvert to relieve runoff from ditches, not associated with stream crossings.

**Cross Ditch:** Deep depression cut across road to move water from ditch and running surface away from road and onto forest floor to reduce erosion from increased volume and velocity of water. For use only on deactivated roads, otherwise it would be a driveable dip.

**Driveable Dip:** Depression cut across road surface to move water from ditch and running surface away from road and onto forest floor to reduce erosion from increased volume and velocity of water. For use on permanent and temporary roads.

**Water bar:** Small depression cut across road tread to move water off of running surface and into ditch line or onto forest floor to reduce erosion from increased volume and velocity of water.

## Appendix D: Small Stream Assessment

### General

The subject of small stream management has come under increasing scrutiny in the forested landscape. In part this is because small stream management involves more uncertainties and less information than are generally available for assessments and prescriptions involving larger streams. Simpson believes that this HCP represents a significant attempt to characterize and manage small streams in the context of a highly variable landscape. The approach Simpson is proposing should be credited for two things: (1) a significant advance in the level of protection currently afforded the small stream base on private forest lands, and (2) a well designed experiment in small stream management in which the risks to the public resources have been minimized by a careful assessment and classification of the small stream base.

### Small stream base

The group of channel classes assigned to the intermittent flow/unstable slopes (“IFUS”) riparian strategy is the most diverse and difficult to characterize of any that is associated with one of the plan’s riparian strategies. The current regulatory scheme for forest practices in Washington lumps most of these channel types together as Type 4 or 5. Of the 919 miles in this group, 775 miles or 88 percent are classed as 4, 5, or 9. However, virtually all 14 channel classes have some segments that support fish (Table 28).

*Table 28. Miles of channel classes assigned the IFUS strategy by DNR stream type.*

Channel Class	Class Character	Class Miles	DNR Stream Type (miles)					
			1	2	3	4	5	9
AGL-Qo1	Sm, HC, SP <sub>f</sub> /SP	61.4	0.0	0.5	10.5	7.6	26.1	16.7
AGL-Qo2	Sm, MC-UC, PR <sub>f</sub>	22.5	0.0	0.0	7.9	3.5	3.7	7.4
CIS-C1	Sm, HC, SP <sub>f</sub>	84.0	0.0	0.0	4.7	3.0	24.4	51.9
CIS-Qc1	Sm, HC, SP <sub>f</sub>	33.3	0.0	0.0	1.1	1.5	8.8	22.0
CIS-Qc2	Sm, MC-UC, PR <sub>f</sub>	28.1	0.4	0.1	8.5	3.1	4.4	11.6
CUP-C1	Sm, HC, Cas/BD	199.6	0.0	0.0	1.7	55.6	74.1	68.4
ROP-Qc1	Sm, UC, PR <sub>f</sub>	165.7	0.0	2.4	33.9	32.4	36.7	60.3
SIG-L1	Sm, HC, SP <sub>f</sub>	160.0	0.0	0.0	8.1	6.5	57.7	87.7
SIG-M1	Sm, HC, SP <sub>f</sub>	67.8	0.0	0.0	3.9	4.8	33.3	25.8
SIG-M2	Sm, MC, PR <sub>f</sub>	18.5	0.0	0.0	7.7	4.9	4.1	1.8
SIG-Qc1	Sm, HC, SP <sub>f</sub>	12.8	0.0	0.0	1.7	2.4	6.6	2.1
SIG-Qc2	Sm, MC-UC, PR <sub>f</sub>	8.9	0.0	0.0	3.2	0.4	3.3	2.0
SIG-Qo1	Sm, HC, SP <sub>f</sub> /SP	37.7	0.0	0.0	2.6	5.7	16.7	12.7
SIG-Qo2	Sm, MC-UC, PR <sub>f</sub>	18.9	0.0	0.0	10.3	4.4	2.9	1.4
<b>Totals</b>		<b>919.2</b>	<b>0.5</b>	<b>3.0</b>	<b>105.6</b>	<b>135.7</b>	<b>302.6</b>	<b>371.8</b>

### Management approach

Consistent with Simpson’s overall riparian approach, it is the goal of the IFUS riparian strategy to maintain important functional linkages between channel segments and their riparian forests. Even though channel classes assigned this strategy typically have low on site fish resource value, in some instances significant impacts may be transmitted downstream to other channel segments of

the same class or those of other classes for which on site fish resource value is higher. Certain of these channel classes also contain stream breeding amphibian populations and their habitat. In order to optimize both environmental protection and timber harvest opportunity, Simpson's HCP emphasizes a flexible approach to managing the diversity of ecological function and wide range of physical settings in this group of channel classes. Simpson's assessment of the differences between and within classes, and its classification system that organizes those differences, provides the necessary scientific framework for the application of management prescriptions.

### **Reiteration of general management prescriptions**

Appendix B contains specific information on the application of the IFUS riparian strategy. However, a simple reiteration may be helpful here for the sake of continuity and readability of this section. For channel segments where any species of fish are present, a minimum of 3 acres of no harvest buffer per 1,000 feet of channel will be retained in a pattern that optimizes functional benefits for the channel class. Unstable slopes adjacent to any of these channel classes will also be protected with continuous leave areas regardless of the presence or absence of fish. In many cases the unstable leave areas will significantly increase the number of trees retained adjacent to these channel classes. Where no fish are present, and no instability exists, 80 trees per 1,000 feet of stream shall be retained that are representative of the pre-harvest stand in both size and species composition. In these cases, leave trees will be left in patches of at least ½ acre and where they will have a high likelihood of contributing to the functional requirements and ecological roles of the particular channel segments. Such places may include tributary junctions, areas of locally steeper channel slope, areas of locally greater valley width, zones of channel up-welling, or adjacent to seeps and springs. The clumping of leave trees along non fish-bearing portions of these channel classes will provide discontinuous forest fragments for recruitment of LWD and also provide immediate protection for stream breeding amphibians. In those cases where unstable slopes exist upstream from channel segments that would be protected with discontinuous buffers, a continuous buffer of 160 trees per 1,000 feet of channel will be retained in a continuous band adjacent to the channel.

### **Risk assessment**

Three critical areas are addressed below to assist reviewers in evaluating the relative level of risk associated with Simpson's IFUS strategy: (1) the extent of the small stream base available for immediate harvest under these prescriptions, (2) relative physical hazards, and (3) biological resources supported in each of the different channel classes comprising the group. Taken together this information provides a solid basis for evaluating the sufficiency of the overall approach to protecting riparian function and aquatic habitat and the relative level of risk associated with this aspect of the HCP.

### **Extent of small stream base in harvestable age stands**

Table 29 lists the mileage for each channel class that has been harvested to a particular "industry period standard". The last column represents the mileage base that could be harvested immediately under the HCP prescriptions (i.e. mature second growth timber). These numbers may provide a useful index to the current "conservation opportunity" for each channel class. Based on Simpson's log sourcing strategies and projected rotation ages, thirty-seven percent of the channel mileage base assigned to the IFUS strategy is available for harvest today, the rest being in some stage of re-growth following the previous harvest.

### Extent of small stream base receiving protection

*Under the plan proposal 100 percent of the channel mileage will receive protection of some kind, be it continuous buffering for fish or unstable slopes, or discontinuous buffering in the absence of fish and instability. While no figure for the mileage afforded continuous protection by unstable slopes is available for these channel classes, it is anticipated that the additional protection of unstable slopes required by the plan will substantially augment the continuous buffers provided for channel segments supporting fish.*

**Table 29. Estimate of the number of miles harvested to "industry period standards" for each channel class in the IFUS riparian strategy.**

<b>Channel Class</b>	<b>Miles in Class</b>	<b>Pre-FPA</b>	<b>FPA-TFW</b>	<b>TFW-Present</b>	<b>Available</b>
AGL-Qo1	61.4	11.1	2.6	12.0	35.7
AGL-Qo2	22.5	4.1	0.9	4.4	13.1
CIS-C1	84.0	6.7	23.4	28.6	25.2
CIS-Qc1	33.3	2.7	9.3	11.3	10.0
CIS-Qc2	28.1	2.2	7.8	9.6	8.4
CUP-C1	199.6	87.0	11.8	26.6	74.3
ROP-Qc1	165.7	13.9	26.8	62.8	62.0
SIG-L1	160.0	13.9	36.3	52.8	56.8
SIG-M1	67.8	5.9	15.4	22.4	24.1
SIG-M2	18.5	1.6	4.2	6.1	6.6
SIG-Qc1	12.8	1.1	2.9	4.2	4.5
SIG-Qc2	8.9	0.8	2.0	2.9	3.2
SIG-Qo1	37.7	3.3	8.6	12.4	13.4
SIG-Qo2	18.9	1.6	4.3	6.2	6.7
<b>Total</b>	<b>919.2</b>	<b>156.0</b>	<b>156.4</b>	<b>262.3</b>	<b>343.8</b>

### Physical hazards and biological resources

#### *AGL-Qo1*

This channel class occurs at the tip of the channel network in the AGL and runs through glacial tills that are frequently highly cemented and capable of holding steep slopes with little risk of failure. In some cases however, subsurface moisture accumulates and comes to the surface on the over-steepened lower slopes of these low order basins indicating a combination of factors that constitute unstable conditions. Large logs or accumulations of logs from past shallow rapid landslides or logging debris serve to locally stabilize the entire valley floor, which is often no more than 5 meters in width. Owing to this relatively narrow valley, sediment derived from mass wasting of the side slopes is generally deliverable. Shallow rooting of Douglas fir in these soils and the preponderance of western hemlock in these stands makes AGL-Qo1 riparian settings prone to wind damage unless they are topographically sheltered. Woody debris helps to retain sediment and moderate local channel slope in these systems but channel roughness also is supplied by large glacial clasts in the channel bed.

Simpson has recorded relatively high densities of tailed frog and Cope's giant salamanders in those segments draining the western watershed between the West Fork Satsop and the Wynoochee Rivers. Incidental observations in this channel class west of the Wynoochee also

suggest high value to stream breeding amphibians. It appears to be the coarse stream bed and relatively moist conditions of the watersheds that favor stream breeding amphibians in this channel class. In the discontinuous protection reaches, trees will be left adjacent to seeps, which occur with some regularity in the glacial soils. In conjunction with the unstable slopes protection Simpson contends the discontinuous buffers will provide good protection for the principal biological resource, stream breeding amphibians.

#### *AGL-Qo2*

AGL-Qo2 segments connect the upper portions of the channel network in the AGL to the larger channel segments that support anadromous fish production. As sediment sources, they are generally low risk segments due to the more “relaxed” valley topography and channel slopes. The broader valleys (10-30 meters) provide depositional zones for the occasional debris flow that may issue from an AGL-Qo1 tributary or an adjacent over-steepened valley wall resulting in a low risk for transmitting sediment downstream. AGL-Qo2 valleys are floored by wet soils and due to the previous harvest history and natural plant potential are currently supporting early to mid-successional stands dominated by red alder. These sites ultimately have the potential to support western hemlock stands interspersed with western redcedar but may frequently be part of a wet shrub community mosaic due to periodic wind disturbances and delayed conifer succession. These systems have limited capacity to transport and rearrange woody debris and even relatively small diameter logs can make a contribution to habitat character.

Lying as they do between the non-fish bearing portion of the network and the principal fish producing segments, these segments can be important for sustaining resident fish species and amphibians. Protection will come predominately as continuous buffers for fish and management efforts will focus on the identification of fish bearing and perennial segments of this class for continuous protection. Relatively few segments in this class do not support fish - the most common species present are cutthroat trout and riffle sculpin.

#### *CIS-C1*

Channel segments initiating on the basalt islands in the CIS comprise this class (see Section 2). These channels are steep (up to 30 percent) and have a coarse substrate of angular basalt. However, side slopes are stable and these systems pose a low sediment source risk (channel class verification work in approximately 15 segments has recorded very few recent side slope failures). Soils in these glacially over-ridden landscapes are thin and with a few notable exceptions, water storage is poor. Consequently basins as large as 100-120 acres are commonly dry during the summer. This flow regime tends to make them marginal habitat for stream breeding amphibians. Simpson has documented a few exceptions to this general case and in these circumstances the habitat appears to be suitable for Cope’s giant salamanders, tailed frog and cutthroat trout. Simpson has identified one such segment that contains tailed frog and several others that support resident trout and sculpins. Management of this class will focus on opportunities such as these and will require careful inventory so that the exceptional cases are not overlooked.

#### *CIS-Qc1*

The CIS-Qc1 channel class connects the CIS-C1 segments to larger channels of the CIS, either CIS-Qc2 or 3. These segments begin at the boundary of the basalt and the glacial drift that blankets the shoulders of the basalt islands. These segments are also viewed as relatively low risk for sediment principally due to limited fluvial transport capacity and the lack of significant mass wasting. Springs and seeps do occur on the side slopes of these channels and these areas will be

protected. Woody debris functions to form steps in these systems and stabilizes stream banks. Avoidance of groundwater interception and piracy by the ditch system will be an important conservation element for this channel class.

#### *CIS-Qc2*

This channel class is not a high risk for sediment sources, which mainly come from erosion of the stream banks. There are no significant mass wasting issues and where they do occur, the probability of delivery is low due to the relatively wide valleys they typically occupy. Woody debris is important to structure the habitat in these systems and riparian trees also stabilize stream banks. Recent surveys by Simpson indicate that virtually all of the segments in this channel class will require continuous riparian protection for fish.

#### *CUP-C1*

The CUP-C1 channels are significant for several reasons. First there are many miles in this class. Secondly, they are the primary conduits for debris flows in the CUP and as such represent high risks for sediment sources. Debris flows transmitting through these channel segments can, in some cases multiply what may have started as a small quantity many times over before it runs out in larger connecting channel segments. The sediment they deliver to the main canyon systems is routed downstream efficiently where it is deposited in alluvial fan segments at the mouths of the canyons. These downstream segments are important fish habitat for both resident and anadromous species. Thirdly, although on-site biological value for this channel class is quite variable, where they are perennial or even intermittent these segments have high value for stream breeding amphibians including torrent salamanders. Specifically torrent salamanders tend to be found in segments that exceed 30 percent slope in basins of less than 15 hectares. Protection in these segments will focus on slope instability and the identification of the high quality amphibian habitat. Simpson estimates that much of this class will receive continuous protection due to unstable slopes. The road maintenance program, especially the abandonment element, will be a significant conservation measure for this channel class.

#### *ROP-Qc1*

The ROP-Qc1 class represents a varied group of segments that occur on the flat up-slope of the ROP and total 165.7 miles. These segments are comprised of slightly incised and or confined channels that principally function as linkages between wetlands or between the larger streams and wetlands. Due to the impermeable character of some of the glacial tills in this area, the ROP landscape tends to store water poorly, creating a flashy runoff pattern in an otherwise low energy stream environment. These same soils cause Douglas fir (the dominant conifer species in these stands) to have very shallow root systems which make them especially susceptible to windthrow. Woody debris is not particularly important in the habitat development of this channel class. Low gradient and plentiful water seasonally encourages relatively deep penetration of these systems by a variety of fish species including coho, cutthroat, sculpin, and dace. These systems pose virtually no risk from a sediment perspective, the primary source in the area being ditch line and road surface erosion. Amphibian resources are only of the most common variety including northwestern and western red back salamanders, newts, and red-legged frogs. All of these species are primarily associated with wetlands for breeding. Simpson estimates that only about 26 miles or 25 percent of this class could be completely unencumbered by management prescriptions.

*ROP-Qc2*

The ROP-Qc2 channel class has two distinct members; one in the northern portion of the ROP in the Skokomish River basin and another in the southern portion of the ROP in the Stillwater River basin. The northern member represents a significantly greater risk for physical hazards but is less important biologically with numerous segments seasonally dry and incapable of supporting fish and amphibians. These segments however, have long steep side slopes (10-90 meters long and 70-90 percent slope) and it is relatively common to see side slope failures (0.80 failures per 100 meters) which can generate modest to large amounts of coarse glacial gravels and deposit them directly into small channels. Such channels have a very porous bed and are dry in the summer. The southern members are connecting segments from the larger ROP-Qc series to wetlands or to connecting Qc-1 segments. These segments have much shorter side slopes, but are often in excess of 70 percent and many fewer failures (average 0.23 per 100 meters). Those failures that do occur are minor in nature contributing little sediment to the system. Many of the southern members however, are fish bearing and provide linkages to over wintering habitats. Many of the windthrown trees adjacent to this channel class bridge the channel and there is not a significant functional contribution until the gorge width at the top reaches approximately 40 meters

*SIG-L1*

The SIG-L1 channel class is one of the more inherently unstable channel classes. Physical surveys have recorded steep side slopes (nearly half of the length surveyed had side slopes in excess of 70 percent) with failure rates averaging 1.76 per 100 meters, the highest of any of the small channel classes. These failures appear largely unrelated to management as they occur with some regularity in forested, buffered, and clearcut settings. A few important exceptions to this observation appear to be related to the piracy of water by the road ditch system. Siltstones of the Lincoln formation are highly erodible and woody debris appears to play a role in the stabilization of the channel bed and channel side slopes. The long term role of wood in structuring the channel bed and preventing channel incision, to the degree that it could destabilize side slopes, could be significant. Biological resources on site are minimal. Simpson's assessments indicate that Cope's giant salamander and crayfish are the most common aquatic resources. Western red back and northwestern salamanders, newts, and red-legged frogs are common in riparian areas. The SIG-L1 segments frequently connect downstream to the SIG-L2 segments, which can harbor isolated populations of riffle sculpin. Unstable slopes will result in significant protection for the L1 series. Discontinuous protection will be focused on tributary junctions and areas of steeper than average side slopes. The purpose of leaving patches of timber in these two places respectively, is to provide woody debris for stabilization of areas that can serve as sediment sinks, and to protect the best stream breeding amphibian habitat.

*SIG-M1*

Small first and second order channels in the Montesano sandstone series are classed as SIG-M1 segments. Side slopes in this landscape range widely between 30 and 90 percent; the upper bound being somewhat uncommon. These segments can be high slope stability risks, especially if peak storm flow is augmented through piracy by the road ditch system. Side slope failure rates observed averaged 0.36 per 100 meters. Failures tended to exhibit a very shallow failure plane about 20-30 cm deep. The failure "rind" is the shallow soil that overlies the sandstone bedrock, which occurs as a massive formation. Simpson currently has not done any biological assessments in this channel class but based on the unconsolidated character of the channel substrates, limited value is expected for stream breeding amphibians. However, the M-1 members usually connect to M-2 segments, which are frequently fish-bearing. Often the valley opens up and is quite wide at

the confluence area between M1 and M2 segments. Given appropriate wood loading, this junction area functions as a sediment sink that largely disconnects the upper and lower basin coarse sediment budgets. Protection of this class will focus on steep sided M1 segments and the confluence areas between M1 and M2 segments.

#### *SIG-M2*

M2 segments occupy valleys in the Montesano sandstone formation that are from 8-20 meters wide. These valley bottoms are wet and the channel segments typically are perennial often having small populations of cutthroat, coho, and sculpin. Observed side slopes are less than 70 percent and mass wasting delivery potential is small due to the relatively wide valleys. Sediment in these systems is derived from bank and terrace erosion. Woody debris functions to stabilize the valley bottom, much of it well buried in the valley sediments. However, the current riparian forest is largely hardwood with a few large residual conifer. This channel class is a good candidate for active riparian management such as under planting of shade and moisture tolerant species.

#### *SIG-Qc1*

SIG-Qc1 segments occur as a headwater channels in rolling glacial topography between the Middle Fork and the West Fork Satsop Rivers. As such it is a minor class in our scheme with 12.8 miles total recorded in Simpson's GIS. Simpson is currently conducting channel class verifications for this class and the few fish and amphibian surveys that have been conducted indicate minor value for stream breeding amphibians with some cases of riffle sculpin in isolation, and a few segments with resident cutthroat trout. Some locally steep side slopes may pose infrequently occurring physical hazards for mass wasting.

#### *SIG-Qc2*

The SIG-Qc2 channel class occurs in the same general region of the Plan Area as the SIG-Qc1 segments. These segments are low gradient and often include an open water wetland somewhere within their length. They frequently have cutthroat trout or sculpins and sometimes dace and lamprey. But the distribution of any of these species is somewhat discontinuous within this highly variable channel class. These segments will convey little if any coarse sediment to downstream segments due to the contiguous wetlands which interrupt sediment routing within their basins.

#### *SIG-Qo1*

SIG-Qo1 segments are at the tip of the channel network along the western divide between the AGL and the SIG. Segments of this class are geomorphically very similar to some AGL-Qo1 segments. The highest tailed frog densities recorded in Simpson's stream breeding amphibian surveys occur in segments of this class. Side slopes are variable between 40 and 70 percent. Channel widths vary from 1-4 meters with valley widths of 6-18 meters. The highly incised escarpment members of this class have a side slope failure rate averaging 0.31 failures per 100 meters. However, for the class as a whole the failure rate averages only 0.08 per 100 meters which reflects the more stable nature of the terrain of the upland members of the class. Management of this class will focus on unstable leave areas in the steeper members of the class and protection of high quality tailed frog habitat.

*SIG-Qo2*

The SIG-Qo2 channel class connects the tips of the channel network with the main incised inner gorge systems of the SIG, principally the SIG-L4 segments. Valley topography is generally quite relaxed with a valley width of 20 meters or more. Channels slopes range from 2-5 percent with a channel bed composed of glacial gravels and cobbles. Most of the riparian areas are very wet today and are dominated by red alder with some cottonwood and miscellaneous hardwood species. Evidence of a conifer forest with large specimen cedar and occasional Douglas fir on higher better drained sites exists. The principal biological resource is riffle sculpin, which are isolated above waterfalls ranging up to 10 meters and more in height. Much of the class will receive continuous protection based on the presence of sculpin.

## **Appendix E: Riparian Monitoring Studies**

### **General**

The following is a brief synopsis of a riparian monitoring project that Simpson conducted in 1996 and will expand under provisions of Section 9 of this HCP. This information is presented in the HCP as one type of documentation for certain aspects of riparian forest baseline conditions.

### **Study Description**

Thirty sites, well distributed across Simpson's ownership, were selected for monitoring (Table 31). Selection criteria required that both sides of the stream had been harvested (except for the riparian leave area) in the past 2-8 years according to DNR guidelines. All sites were adjacent to small to medium size fish bearing streams. The purpose of the project was to document the stand characteristics left after harvest and record the condition of the riparian forest after several years of exposure to the clear-cut edges.

### **Methods**

One-hundred meter total sample reaches were marked on the ground with rebar and iron fence post monuments on each corner at each site. A GPS position was recorded for the downstream right bank corner and is stored in Simpson's GIS. The following site and tree level data were collected to characterize each riparian setting and each tree on the site:

**Site:** LTU; legal description; segment number; channel bed morphology; valley cross sectional; channel width; channel slope; distance to tree height elevation.

**Tree:** Species; DBH; status, (includes standing live, standing stressed, standing dead or down); surface location; moisture class (based on understory vegetation); For all downed trees: azimuth of fall; cause of fall; in channel or not; distance to channel; distance to clearcut edge; channel interaction. All trees 10 cm DBH or larger were recorded. Traverses of all sites were recorded to calculate the total forested acreage and to provide a method of reestablishing the monitoring boundaries in the future.

### **Results**

4,528 stems (2,005 conifer and 2,523 hardwood) were measured in a combined area of 25.45 acres for the 30 sites. Species composition, the number of trees and basal area per acre between sites were highly variable (Table 32, Figure 14). The numbers in Table 32 are independent of the status of the stem and as such generally represent the stand as it existed at the time of harvest. Perhaps the most interesting result of this study is how riparian stand conditions are changing with time after harvest. There is a substantial mortality due to windthrow and stress presumably as a result in micro-climate change and exposure to the exposed clearcut edge (Figure 15). The directional signal for wind thrown trees is especially strong for conifer (Figure 16) and has significant implications for riparian guidelines (Figure 17). The edge trees in riparian buffers suffer substantial damage but some damage is spread throughout the entire buffer (Figure 18 and Figure 19). These combined results suggest that wider riparian reserves (widths observed in this study were all measured from the "ordinary high water mark") will better support riparian forest function but that the windward side is especially important to consider in wind sensitive settings. The results also suggest that a highly diverse riparian forest is developing that will have many

beneficial components for both aquatic and terrestrial species. However, due to some of the disturbance effects of the clear cut edges, the trajectory for improvement for riparian systems on managed forest lands may be somewhat flatter than simple models predict. Snags, for example, are being recruited through natural processes (Table 30) but this mortality removes other functions such as shade that those trees were providing previous to harvest.

**Table 30. Conifer snag density in riparian monitoring sites (number per acre).**  
*Seventy percent of all snags were hard with 80 percent of the soft snags occurring in the small category. This is currently the best information existing on snag density for the RCR.*

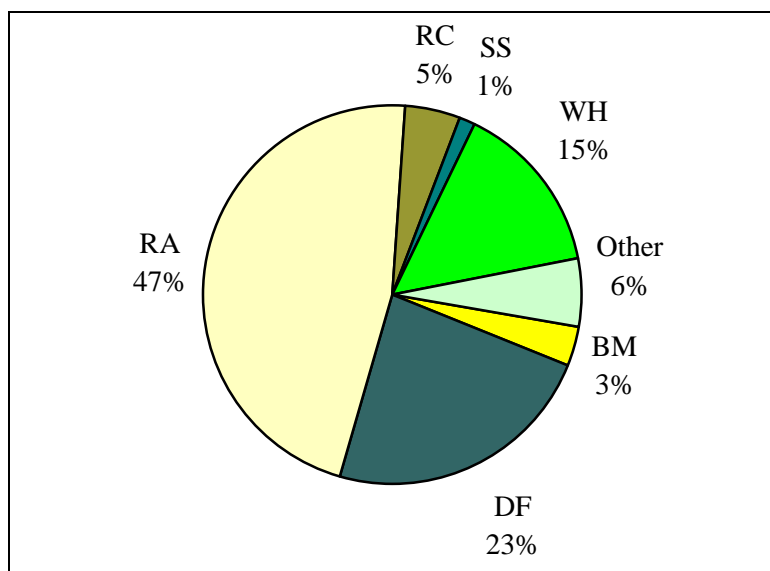
Species	10-30 cm	30-60 cm	> 60 cm
Douglas Fir	4.44	0.86	1.02
Western Red Cedar	0.08	0.00	0.00
Sitka Spruce	0.04	0.04	0.00
Western Hemlock	1.14	0.16	0.12
<b>Total conifer</b>	<b>5.70</b>	<b>1.06</b>	<b>1.14</b>
<b>Grand total</b>	<b>7.90</b>		

**Table 31. Permanent riparian monitoring sites maintained by Simpson.**

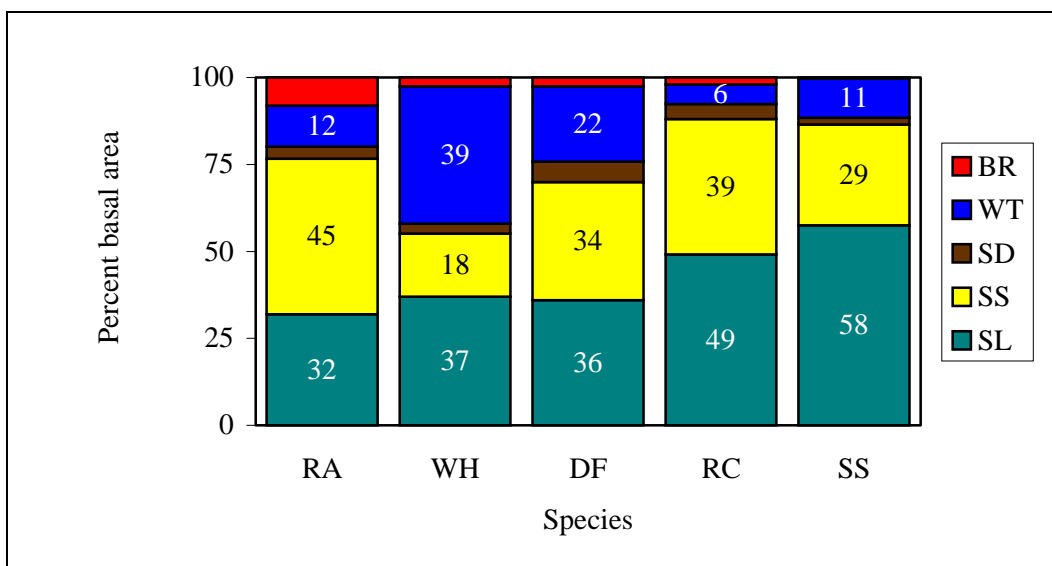
Stream	GIS Segment No.	LTU	Location (Sec, T, R)
Gosnell Ck. trib.	17965	CIS	SE1/4,NW1/4; 15; 19/4
Gosnell Ck. trib.	19054	CIS	SE1/4,NW1/4; 12; 19/4
Beaver Ck.	20489	ROP	SE1/4,SE1/4; 36; 20/6
Overlook Ck.	20577	ROP	SW1/4,NE1/4; 1; 19/6
Dry Bed Ck.	20789	ROP	NE1/4,SW1/4; 3; 20/6
Outlet Ck. lower	21084	ROP	SW1/4,SW1/4; 36; 20/6
Outlet Ck.	21085	ROP	NE1/4, NE1/4; 36; 20/6
Outlet Ck upper.	21087	ROP	NE1/4,NW1/4; 19; 20/5
Bingham lower	21088	ROP	SW1/4,NW1/4; 36; 20/6
Stillwater trib.	21887	ROP	NW1/4,NE1/4; 32; 20/5
Carter Ck. trib.	22011	AGL	SE1/4,NE1/4; 31; 20/7
Black Ck. trib.	23563	SIG	NE1/4,SW1/4; 20; 20/7
Likes Ck.	24231	ROP	SW1/4,NW1/4; 15; 20/4
Schafer trib.	24639	AGL	NE1/4,SE1/4; 13; 20/8
Replinger Ck.	24875	SIG	NE1/4,SW1/4; 10; 20/7
Wynoochee trib.	24979	AGL	NE1/4,NE1/4; 14; 20/8
Sandstone Ck. trib	25575	SIG	SE1/4,NE1/4; 8;20/7
Sandstone Ck.	25687	SIG	NW1/4,NW1/4; 9; 20/7
Bingham Upper	26164	ROP	NE1/4,SW1/4; 31; 21/5
Sandstone Ck. trib	26573	SIG	SW1/4, SW1/4; 33; 21/7
Stouder Ck.	26719	SIG	SE1/4,SE1/4; 33; 21/7
Cermak Ck.	26821	SIG	NW1/4,SE1/4; 35; 21/7
Bingham trib.	26918	ROP	NW1/4,NE1/4; 31; 21/5
Wildcat Ck.	27439	SIG	SE1/4,SE1/4; 25; 21/7
Rabbit Ck.	27823	ROP	SW1/4,SE1/4; 21; 21/6
Bingham trib.	27933	ROP	SW1/4,SE1/4; 21; 21/5
North Mt. Ck	28412	ROP	SE1/4,NE1/4; 20; 21/5
Devils Club Ck.	30161	SIG	NW1/4,NE1/4; 16; 21/7
Save Ck.	30620	AGL	NW1/4,NE1/4; 18; 21/7
Frigid Ck.	35525	ROP	N1/2,NE1/4; 23; 22/5

**Table 32. Stand characteristics of riparian monitoring sites maintained by Simpson.**

GIS Segment No.	Stream	Trees per Acre			Basal Area		
		Con.	Hdwd.	Total	Con.	Hdwd.	Total
26821	Cermak Creek	11.6	215.2	226.9	72.6	96.5	169.0
26719	Stouder Creek	16.3	164.1	180.3	53.6	139.8	193.4
20577	Overlook Creek	17.5	133.8	151.3	174.8	32.6	207.4
17965	Gosnell Creek trib	19.8	129.1	148.9	37.9	112.2	150.1
26164	Upper Bingham	29.1	133.8	162.9	54.0	149.7	203.7
20789	Dry Bed Creek	31.4	80.3	111.7	173.4	12.2	185.6
21087	Upper Outlet	32.6	136.1	168.7	160.5	2.9	163.4
26573	Sandstone Creek trib	32.6	167.5	200.1	27.6	105.3	132.8
20489	Beaver Creek	37.2	26.8	64.0	216.4	98.4	314.8
30620	Save Creek	62.8	192.0	254.8	282.8	5.3	288.1
24231	Likes Creek	65.2	15.1	80.3	92.7	88.8	181.5
24639	Schafer Creek trib	71.0	60.5	131.5	132.0	81.4	213.4
27933	Bingham Creek trib north	72.1	94.2	166.4	174.8	21.6	196.4
21887	Stillwater River trib	73.3	7.0	80.3	158.9	65.7	224.6
19054	Gosnell Creek trib	74.5	111.7	186.2	176.3	25.8	202.2
27823	Rabbit Creek	78.0	112.9	190.8	166.3	11.1	177.4
24875	Replinger Creek	80.3	24.4	104.7	179.1	84.6	263.7
24979	Wynoochee River trib	80.3	30.3	110.5	92.0	105.0	197.0
25687	Sandstone Creek	83.8	128.0	211.8	51.5	158.5	210.0
23563	Black Creek trib	86.1	116.3	202.4	46.3	112.2	158.4
21085	Middle Outlet	88.4	17.5	105.9	39.5	118.1	157.7
21088	Bingham Creek	96.6	96.6	193.1	28.5	149.3	177.7
28412	North Mountain Creek	100.1	47.7	147.8	175.2	35.5	210.7
22011	Carter Creek trib	112.9	116.3	229.2	153.0	86.2	239.2
25575	Sandstone Creek Upper	126.8	150.1	276.9	93.4	93.1	186.5
21084	Lower Outlet	131.5	24.4	155.9	67.5	112.7	180.3
27439	Wildcat Creek	132.6	87.3	219.9	272.9	60.7	333.5
35525	Frigid Creek	147.8	57.0	204.8	121.0	86.4	206.9
26918	Bingham Creek trib south	158.2	36.1	194.3	84.5	98.7	183.2
30161	Devils Club Creek	182.7	223.4	406.1	159.8	25.2	185.0
<b>Average</b>		<b>77.8</b>	<b>97.8</b>	<b>175.6</b>	<b>124.0</b>	<b>79.2</b>	<b>203.1</b>



**Figure 14. Species composition for the combined sample of all stems for the 30 riparian monitoring sites maintained by Simpson (N=4,528).**  
 DF= douglas fir, RC= western redcedar, WH= western hemlock, SS= sitka spruce, BM= big leaf maple, RA= red alder, other is incidental species.



**Figure 15. Status of all stems (total basal area) by species.**  
 SL= standing live; SS= standing stressed; SD= standing dead (sang); WT= windthrow; BR= broken (usually due to wind snap).

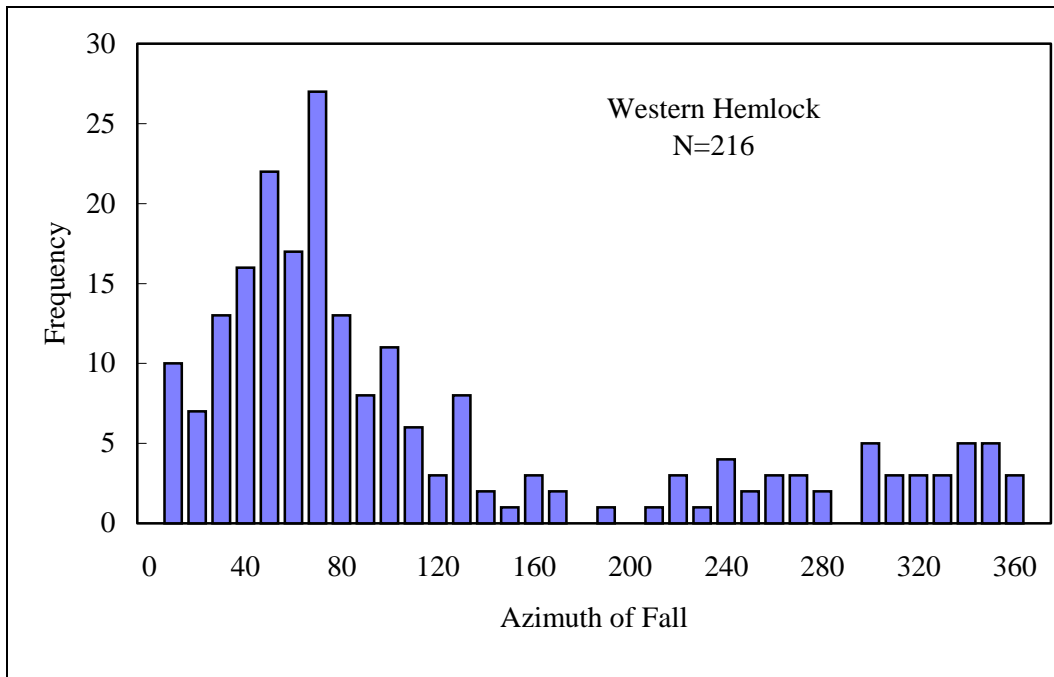


Figure 16. Directional signal for wind thrown western hemlock.

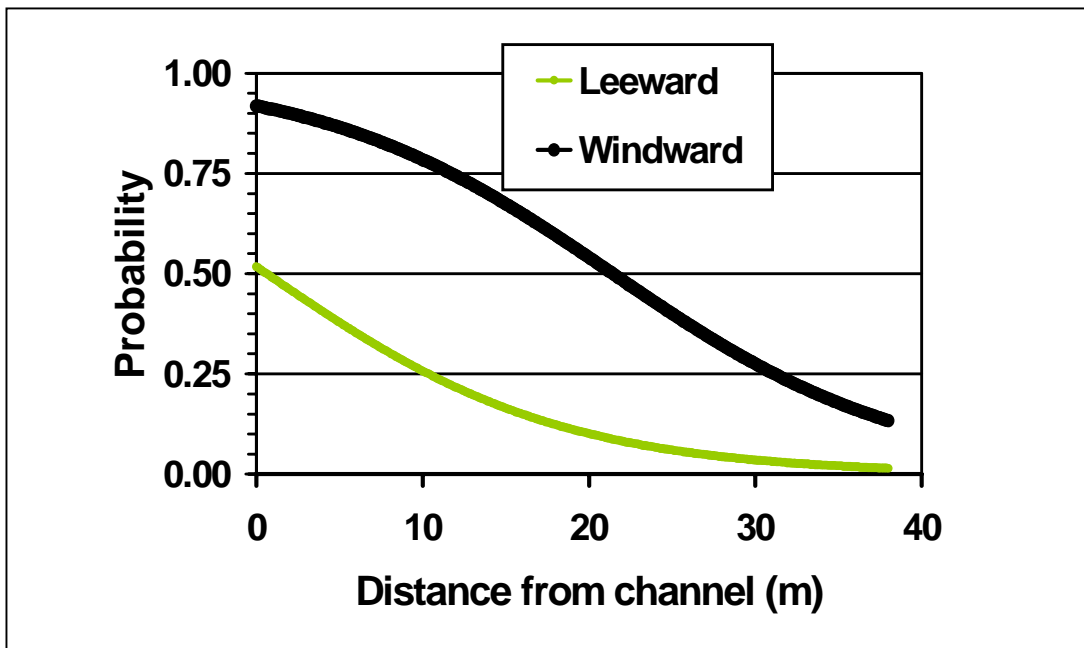
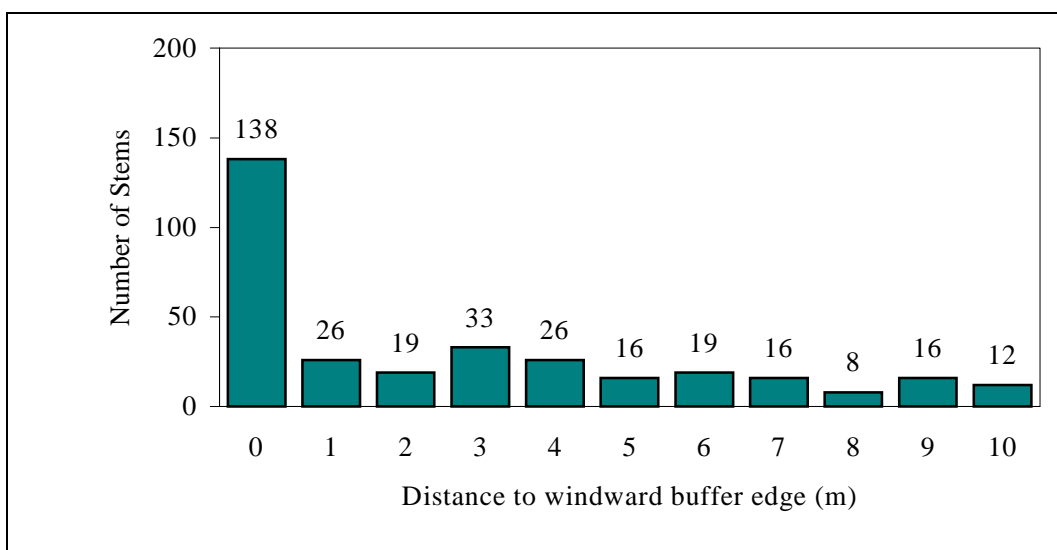


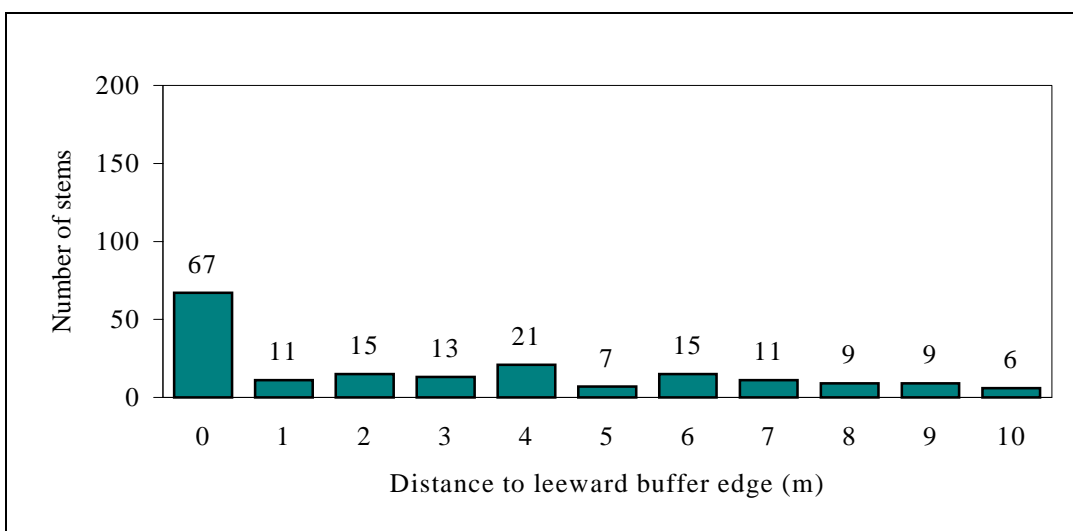
Figure 17. Probability of wind thrown conifer contributing to channel function on windward and leeward stream banks (N=581).

Functional contribution conservatively defined as “any part of the tree breaking the plane of the bank full channel”.



**Figure 18. Distance to buffer edge (clear cut) on windward side of stream for wind thrown and wind snap conifer stems.**

Pattern of damage suggests that a significant portion of the damage (42 percent) occurs at the buffer edge.



**Figure 19. Distance to buffer edge (clear cut) on leeward side of stream for wind thrown and wind snap conifer stems.**

Pattern of damage suggests that a significant portion of the damage (36 percent) occurs at the buffer edge.

## **Appendix F: Changed Circumstances**

### **General**

The forest ecosystems on Simpson's lands are the context within which the management prescriptions were designed. These ecosystems are by no means static; they are dynamic, regularly impacted by various physical processes that shape and reshape the habitat for the affected species that occupy those lands. Indeed, the many aquatic and wildlife species for whose conservation this plan is crafted evolved in close association with this ever-changing mosaic of physical and biological elements.

The relationship between fire, flood, and other physical processes in the structure and composition of forest communities and stream systems has been appreciated for a considerable period of time. In general, there is a growing awareness of the role and importance of fire, and windstorms and other more localized disturbance agents, in the maintenance of animal communities and habitat within the North American landscape, including the Pacific Northwest coastal forests. (*See e.g.*, Franklin & Dyrness 1973; Brown 1985; Henderson, et. al. 1989; Morrison & Swanson 1990; Agee 1991, Reeves et. al. 1995).

The physical processes that affect the biodiversity and landscape ecology of Simpson's lands are usually of moderate intensity and relatively confined in geographic extent and magnitude of impact. Nonetheless, historically in some forest environments covered by this HCP, physical processes have been of catastrophic intensity, particularly from the standpoint of impact to individual plants and animals, and these events can affect large areas of the forested landscape. That these physical processes can significantly alter stream and forest habitat has been a substantive consideration in the development of this HCP. In fact, the intent of the HCP is to minimize management-related disturbances and create conditions that enable natural disturbances to create productive habitat.

Simpson recognizes that the temporal and spatial configurations of future natural disturbances (and their specific related effects on the aquatic and wildlife species covered under the HCP) are inherently unpredictable. The fact that certain types of natural disturbances will occur at some time during the term of this Plan and at some location in the Plan Area is, however, reasonably foreseeable and likely. The management prescriptions set forth in Section 5 were designed, in large part, to be responsive to historic disturbance patterns. Indeed, many of the prescriptions are intended to develop a landscape capable of delivering valuable functions and input in response to such natural disturbances. Therefore the occurrence of most natural disturbances will not create conditions that should require the implementation of revised prescriptions.

Certain reasonably foreseeable disturbances, however, may be of such a magnitude, occur with such an "impulse", or impact such particular portions of the Plan Area as to require the application of supplemental prescriptions for the protection of the covered species. These supplemental prescriptions are set forth below. (Except as otherwise noted, implementation of these additional measures will not be deemed "adaptive management" for purposes of this Plan and the costs of implementing such measures will not be applied against the adaptive management cap.) Except as described in the following subsections, however, any other change in circumstances will be adequately addressed by the application of the Section 5 prescriptions (as the same may be adjusted from time to time by the application of adaptive management under Section 10 hereof).-

## **Fire**

### *The Role of Fire on the Olympic Peninsula*

Fire is a significant agent in determining forest structure in the Pacific Northwest, but its effects, intensity, and frequency vary considerably (Agee & Edmonds 1992). Although it is possible to generalize that fire is an important element of forest ecology, it is not possible to specify the temporal or spatial effects of fire for any given area. This is so because invariably, fires are not uniformly distributed through time (Morrison & Swanson 1990), the areas affected often differ markedly (Henderson et. al, 1989), and the intensity and scale vary considerably (Morrison & Swanson 1990). Regional examples of the role of fire over the past several hundred to a few thousand years demonstrate this variability.

Fire history of the Olympic Peninsula is reasonably well documented for the last 1,000 years (from tree ring counts) but prior to that, only inferences can be made based on charcoal in core samples from bogs and lakes and other paleoecological evidence (Henderson et. al. 1989). Three periods of extensive forest burning have occurred on the Olympic Peninsula during the past 700 years. All three of these periods saw many fires burning and joining together in some cases to cover over a million acres on the Peninsula alone. The first was a very large fire in about 1308, the second burning occurred over a 90 year period between 1448-1538 with the largest fire of the period occurring in about 1508, and the third period was between 1668 and 1701, with the largest fire of the period occurring in about 1701 covering more than a million acres on the Peninsula alone (Henderson et. al. 1989). Simpson is piecing together the fire history of the Plan Area under contract to the U. S. Forest Service. So far this work has documented two other large fires not common to other parts of the Olympic Peninsula that burned in the Wynoochee River watershed, in about 1442 and 1571 (Peter and Henderson 1996). Many smaller fires have burned in the Olympics and parts of the Plan Area since settlement but none have been of the magnitude represented by these large fires which appear to have been driven primarily by climatic variation. Of these smaller fires the two largest, in the neighborhood of 30,000 acres, occurred in the dryer east and north portions of the Peninsula. Only three others exceeded 10,000 acres and most of these were less than 5,000 acres.

In light of this analysis, it is not reasonably foreseeable that large-scale, stand-replacing fires (i.e. a fire covering more than 10,000 acres) will occur on Simpson's lands during the life of this HCP. Thus, it is unnecessary to provide for new, different, or additional mitigation or conservation, including management restrictions or reserve configurations, based on any speculation that such events could occur, as these events qualify as unforeseen circumstances. Certain supplemental procedural prescriptions, however, will be applicable in the event of smaller fires.

### *Fire .Supplemental Prescriptions*

If during the term of the Plan, a small fire (less than 10,000 acres) shall occur in the Plan Area, Simpson may take all measures reasonably necessary to extinguish the fire, including measures that deviate from the Section 5 prescriptions. The strategy for responding to and suppressing forest fires is generally established by the Washington Department of Natural Resources and Simpson may have little ability to influence such strategy. However, to the extent reasonably possible and where consistent with the primary goal of containing and extinguishing the fire, Simpson will encourage the development of a fire-response strategy that is consistent with the Section 5 prescriptions and that furthers rather than diminishes the functions that such prescriptions have been designed to provide.

If the fire involves more than 50 acres in the CUP and AGL, 100 acres in the CIS and SIG, or 500 acres in the ROP, Simpson will provide both Services with information regarding the fire within 30 days. Once such a fire is extinguished and unless such fire is an "unforeseen circumstance", i.e. greater than 10,000 acres, Simpson and the Services will confer to establish appropriate supplemental or changed

prescriptions for further harvest activities in the fire zone. These additional or changed prescriptions will be established consistent with the following principles:

- (a) Simpson will not be allowed to remove more timber than it would have been allowed to remove under Section 5 had no fire occurred in the stand unless the Services determine that the removal of such additional timber would not materially reduce the functional benefit of such habitat for any covered species.
- (b) The removal of all standing or downed trees and the conduct of all other salvage or post fire operations shall be done with reasonable care to minimize soil erosion and to retain adequate structural features within the fire zone consistent with provisions in Section 5.
- (c) Preservation and development of habitat legacies created by the fire (e.g. upland snags) that are consistent with future management of the stand and the provisions in Section 5 will be sought.
- (d) Reforestation of the RCRs consistent with (c) above will be implemented.

## Wind

### *The Role of Wind on the Olympic Peninsula*

Brief but violent windstorms sometimes wrack the Northwest Coast including the Olympic Peninsula, starting as tropical typhoons and carried to land by the jet stream (Lily 1983). The historical record shows a small number of hurricane force storms hit the coast in the last 200 years, two of which had winds in excess of 150 mph (Henderson et. al 1989). The most widespread and violent of these storms were the 1921 storm, referred to as the “Big Blowdown” by early residents of the Peninsula, and the Columbus Day storm of 1962. Both of these storms blew down billions of board feet of standing timber (Pugh 1963), but occurred before riparian buffers were common place features in managed forests of the Northwest.

Over the last decade (during which time riparian buffers have been frequently employed), this region has experienced some locally strong winds, on the order of 50-70 mph. While these winds are easily strong enough to uproot trees, severe disturbances have always been localized in the Plan Area (*See* discussion, Appendix E). Windthrow in riparian buffers is expected in the future, but based on Simpson’s experience, the reasonably foreseeable effect of such windthrow will be limited to individual trees or small clumps of trees. This windthrow is normal across the managed landscape and an expected part of the forest ecology and was contemplated when the mitigation measures for this plan were designed.

Small-scale windthrow is not expected to have a long-term significant adverse impact on stream shading or water temperatures and will have the beneficial effect of introducing large woody debris into streams that currently lack this habitat-forming element. Thus, small-scale windthrow does not pose so substantial an impact as to threaten an adverse change in the status of any Permit or Plan species, and may actually benefit aquatic species through natural modifications to stream habitat. Based on historic experience within the Plan Area, a windstorm that results in the complete blow-down of more than 300 meters, measured along the length of the stream, of trees within an RCR, however, is not reasonably foreseeable, and would be considered an unforeseen circumstance.

### *Windthrow Supplemental Prescriptions*

If a windstorm results in the complete blow-down of more than 100 meters of previously standing timber, measured along the length of the stream, Simpson will provide both Services with information regarding

such windthrow within 30 days of its discovery. With respect to such windthrow, and unless such windthrow constitutes an “unforeseen circumstance”, i.e. greater than 300 meters complete blow-down, Simpson and the Services will confer to establish appropriate supplemental or changed prescriptions for salvage harvest of the windthrow. These additional or changed prescriptions will be established consistent with the following principles:

- (a) Simpson will not be allowed to remove more timber than it would have been allowed to remove under Section 5 had such stand not been the subject of such a wind storm unless the Services determine that the removal of such additional timber would not materially reduce the functional benefit of such habitat for any Permit Species.
- (b) The removal of all downed trees and the conduct of all other salvage or post windstorm operations shall be done with reasonable care to minimize soil erosion and to retain adequate structural features within the wind-damaged area consistent with provisions in Section 5.
- (c) Preservation and development of habitat legacies created by the windstorm (e.g. upland downed woody debris and broken standing trees) that are consistent with future management of the stand and provisions of Section 5 will be sought.
- (d) Reforestation of the RCRs consistent with (c) above will be implemented.

## **Landslides**

### *The Role and Effects of Landslides on the Olympic Peninsula*

Landslides are known to have local and often significant impacts on the character of physical stream habitat and their biological communities. However, landslides and earthflows of many dimensions and driving processes are a natural part of the forested landscape in the Pacific Northwest, replenishing channels with gravel and wood derived from valley slopes and tributary systems (Benda 1990). Without the catastrophic transfer and replenishment of these materials, the habitat of streams in this region ultimately simplifies, supporting fewer species and a less diverse fish community (Reeves et. al. 1995). Thus while the short term effects of landslides can devastate local populations of aquatic vertebrates, landslides and their legacies can actually serve to preserve and perpetuate the habitat that they require and support long term persistence of metapopulations. Logging and road building activities have increased the rate of mass wasting across large areas and changed the character and diminished the quantity of wood they deliver to streams. It is the intent of this Plan to reduce management related landslides and develop forest conditions that enable natural landslides to deliver sufficient quantities and quality of wood for the creation of productive stream habitat.

Landslide rates and processes differ between LTUs with the highest rates being associated with the SIG and the CUP. In the CUP shallow rapid landslides and debris flows are the most common kinds of landslides, whereas the SIG landscape is prone to SR processes on river and stream escarpments in the Montesano sandstone, and relatively small slumping and large persistent deep seated landslides in siltstone lithologies. In the CIS, unconsolidated sandy soils are subject to slumping and flowage type landslides while the AGL landscape produces shallow rapid landslides that occur on slopes underlain by compact glacial till acting as bedrock. These different landscapes with their particular mass wasting processes present varying sensitivities to management activities. Conservation and mitigation measures for within this plan were designed to address sediment and other habitat effects from past landslides, to take advantage of future naturally-occurring landslides, and through a comprehensive series of stream buffer prescriptions, land management restrictions, slope stability analyses, and sediment monitoring, to

avoid significant adverse impacts from management related landslides and mass wasting events in the future.

Generally, landslides that cause alteration of the in-stream habitat condition in any watershed are part of the ordinary ecology of the forested landscape and are adequately addressed by the existing conservation and mitigation measures. Based on historic experience within the Plan Area, a landslide that results in the delivery of more than 250,000 cubic meters of sediment is not reasonably foreseeable, i.e. an unforeseen circumstance.

#### *Landslides Supplemental Prescriptions*

If a landslide results in the delivery of more than 10,000 cubic meters of sediment to a channel (either from a source area or from combined source area and propagated volumes; may represent a shallow rapid landslide of between 1 and 2 hectares or a debris flow between 300 to 600 meters long), Simpson will provide both Services with information regarding such landslide within 30 days of its discovery. With respect to such a landslide, and unless this landslide constitutes an “unforeseen circumstance”, i.e. delivery of more than 250,000 cubic meters, Simpson and the Services will confer to determine if it is reasonably possible that management activities on or adjacent to the area of the landslide could have materially contributed to causing such landslide. If either Service or Simpson concludes that it is reasonably possible that management activities materially contributed to the occurrence of such a landslide, Simpson, at its own expense, will retain a qualified geo-technical expert to analyze the slide and develop a written report. (Minimum qualifications for said expert shall be certification for Level II Washington State Watershed Analysis mass wasting module). The report will include, at a minimum, an assessment of the factors likely to have caused the slide and any changes to management activities which had they been implemented on or adjacent to the area of the slide would have likely prevented the slide from occurring. Upon receipt of such a report, Simpson will forward the report to the Services. Simpson will also make such report available to the SAT prior to its next scheduled meeting. Where appropriate, the recommendations set forth in the report may form the basis for adaptive management changes to the unstable slopes prescriptions under Section 10 of this Plan

#### **Floods**

Floods are a natural and necessary component of stream ecosystems. For example, floods transport and sort sediment, deposit fine sediments, organic materials and chemical nutrients onto flood plain surfaces, recruit large woody debris, and scour pools and create other beneficial aquatic habitats. Changing river courses also periodically provide opportunities for the establishment of new riparian stands. Alluvial terraces along river valleys provide ideal growing conditions for hardwood and conifer stands and are one of the most dynamic vegetative mosaics in the forested landscape. The aquatic component of the HCP recognizes the dynamic nature of channel networks and accounts for the effects of flood by, among other things, prohibiting harvest in channel migration or channel disturbance zones, allowing for natural floodplain processes to positively amplify the effects of flooding on aquatic systems.

Floods that are lesser in magnitude than a 100-year recurrence interval event (i.e., less than a 100-year flood) are part of the expected normal ecology of the forest. The mitigation and conservation measures in the plan are adequate mitigation for such floods. Based on historical evidence in the Plan Area, a flood that is greater in magnitude than a 100-year recurrence interval event is not reasonably foreseeable.

## **Insect Infestations**

Although forest pest infestations have not played a significant historic role in evolution of western Washington forests, occasional outbreaks may occur.

### *Insect Infestations - Supplemental Prescriptions*

If an insect infestation occurs that poses an economic threat to Simpson, this would be considered a changed circumstance and Simpson and the Services will confer to establish appropriate supplemental or changed prescriptions for salvage harvest of the damaged timber. These additional or changed prescriptions will be established consistent with the following principles:

- (a) Simpson will not be allowed to remove more timber than it would have been allowed to remove under Section 5 had such stand not been the subject of such an insect infestation unless the Services determine that the removal of such additional timber would not materially reduce the functional benefit of such habitat for any Permit Species.
- (b) The removal of all timber and the conduct of all other salvage or post salvage operations shall be done with reasonable care to minimize soil erosion and retain adequate structural features within the affected area consistent with the provisions in Section 5.
- (c) Preservation and development of habitat legacies created by the insect infestation (e.g. upland snags) and that are consistent with future management of the stand and the provisions of Section 5 will be sought.
- (d) Reforestation of the RCRs consistent with (c) above will be implemented.

## **Earthquake**

The region in which Simpson's lands are located has experienced infrequent earthquakes. Generally in the forest environment, while localized landslides or tree throw may result from earthquakes, rarely are such events the source of significant aquatic or wildlife habitat impacts. However, coincident with a major earthquake that hit the Puget Sound region about 1,100 years ago, mass wasting created landslide-dammed lakes in several Olympic Peninsula headwater streams, including one in the Plan Area, Lower Dry Bed Lake (Logan et al. 1998). Earthquakes like the one a millennium ago that are of such magnitude to substantially alter aquatic systems or require additional conservation or mitigation measures are not reasonably foreseeable during the life of the HCP. Earthquake-caused landslides, if any, will be addressed pursuant to the "Landslides" subsection of this Changed Circumstances section.

## **Appendix G: Clean Water Act TMDL**

### Appendix G: Clean Water Act TMDL: Technical Assessment Report

Set forth below is a draft TMDL technical assessment report prepared by the Environmental Protection Agency (EPA) in consultation with the Washington State Department of Ecology (DOE) pursuant to the Clean Water Act.

One of the unique features of Simpson's HCP has been the close coordination between the Services and the state and federal agencies responsible for the implementation of the Clean Water Act. From the outset, Simpson has sought to structure a management regime and related analysis for its properties that would satisfy the requirements of Section 10 of the ESA as well as provide a theoretical framework for the preparation of a TMDL.

The development of this HCP and the development of the draft TMDL technical assessment report have proceeded simultaneously along parallel tracks. Although neither is legally dependent on the other, much of the information and analysis developed for the preparation of the HCP has been useful in developing the TMDL and vice-versa. Specifically as it relates to the HCP, Simpson has been informed that the Services have carefully considered the analysis developed by EPA and DOE in independently evaluating whether Simpson's HCP satisfies the requirement of Section 10 of the ESA. Pursuant to Section 9 and 10 of this HCP, if the sediment or heat load allocations identified in the TMDL are not achieved, the management prescriptions of this HCP may be subject to modification.

It is important to note that the TMDL is a document prepared solely by EPA in consultation with DOE. As such, Simpson has not had a significant role (beyond providing certain baseline data and developing the landscape management framework) in the preparation of, or the development of the analysis set forth in, the attached TMDL technical assessment report. It is attached as an appendix to this HCP solely for information purposes. Simpson has been advised that DOE and EPA intend to seek public comments on the TMDL in a separate forum which roughly parallels the public review period for the HCP. It may be that further changes will be made to the attachment based on comments received by DOE and EPA at such time

**APPENDIX G**

**Simpson Northwest Timberlands**

**Total Maximum Daily Load (TMDL)**

***Technical Assessment Report***

*August 1999*

The following appendix is a draft TMDL technical assessment report prepared by the Environmental Protection Agency (EPA) in consultation with the Washington State Department of Ecology pursuant to the Clean Water Act.

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It is important to note that the TMDL is a document prepared solely by EPA in consultation with Ecology. As such, Simpson has not had a significant role (beyond providing certain baseline data and developing the landscape management framework) in the preparation of, or the development of the analysis described in the attached TMDL technical assessment report. It is attached as an appendix to this HCP solely for information purposes. Simpson has been advised that Ecology and EPA intend to seek public comments on the TMDL in a separate forum which roughly parallels the public review period for the HCP. It may be that further changes will be made to the technical assessment report based on comments received by Ecology and EPA at such time.

# **Simpson Northwest Timberlands Total Maximum Daily Load (TMDL)**

## ***Technical Assessment Report***

*August 1999*

A Total Maximum Daily Load (TMDL) has been developed to address fisheries concerns on several tributaries of the lower Chehalis and Skokomish Rivers as well as several streams draining to South Puget Sound and Hood Canal. The scope of this TMDL includes waters located on land owned by Simpson Timber Company (STC) in the State of Washington. These forested watersheds include Simpson's commercial timberland in Thurston, Mason, and Grays Harbor counties. The area lies near Shelton and extends into the southern foothills of the Olympic mountains across the Wynoochee River.

Excessive summer water temperatures in some of these streams reduce the quality of rearing habitat for coho salmon as well as for steelhead and cutthroat trout. Primary watershed disturbance activities which contribute to surface water temperature increases include forest management within riparian areas, timber harvest in sensitive areas outside the riparian zone, and roads. As a result of water quality standards (WQS) exceedances for temperature, four waters in this TMDL area are included on Washington's 1996 §303(d) list. The TMDL also addresses sediment inputs associated with road management and hillslope failures that contribute to temperature problems.

A Habitat Conservation Plan (HCP) was developed by Simpson in accordance with the Endangered Species Act [ESA §10]. It describes a suite of management, assessment, and monitoring actions. A lithotopo classification and channel description system serve as its fundamental basis. Simpson's conservation program emphasizes the protection of riparian forests coupled with erosion control as a primary strategy to satisfy ESA §10. Activities to be covered include all aspects of Simpson's forest practices and related land management (mechanized timber harvest, log transportation, road construction / maintenance / restoration, etc). Specific management prescriptions designed to reduce the input of pollutants into streams within the Plan area include:

- ! Riparian Conservation Reserves
- ! Road Management
- ! Unstable Slope Protection
- ! Hydrologic Mature Forest Development
- ! Wetlands Conservation Program

Habitat assessment and monitoring will also be conducted by Simpson using adaptive management to validate assumptions made as a "*margin of safety*" within the TMDL and to evaluate the effectiveness of specific management prescriptions.

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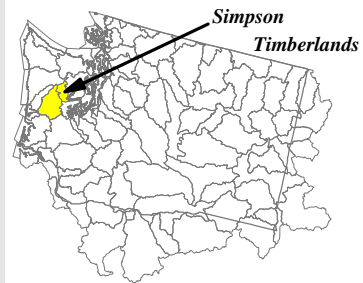
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# Simpson Northwest Timberlands Total Maximum Daily Load (TMDL) *Technical Assessment Report*

August 1999

## TMDL AT A GLANCE:

**Subbasins:** Lower Chehalis, Skokomish, S. Puget Sound  
**Key Resource:** Chinook, Coho, & Chum Salmon  
 Steelhead Trout  
 Cutthroat Trout  
**Uses Affected:** Salmonid Spawning & Rearing  
**Impairment:** Water Temperature Increases  
**Pollutants:** Heat (Solar Radiation)  
 Sediment  
**Sources Considered:** NPS - Forest Practices, Road  
 Construction



## 1. SUMMARY

This Total Maximum Daily Load (TMDL) is being established for two pollutants: heat and sediment. The TMDL is designed to address impairments due to surface water temperature increases on four listed water quality-limited segments located within Simpson's 261,575 acres of Northwest Timberlands in the State of Washington. The two pollutants considered in this TMDL, singly and in concert, are major determinants of water quality that affect aquatic life. These factors vary naturally in their characteristics across the landscape (as a function of geology, topography and climate) as well as over time. The influence of both pollutants on water quality can also be significantly affected by changes associated with land use.

This TMDL uses two "*other appropriate measures*" (or surrogates) to address water temperature increases: percent effective shade and sediment delivery. Higher heat load values, which elevate surface water temperatures, result from a combination of riparian vegetation removal and / or channel widening. Riparian vegetation removal decreases shade available to block sunlight (i.e. incoming solar radiation) and the resultant heat transfer to the stream. Sediment affects water temperature by increasing channel widths and the water surface area exposed to sunlight.

### Scope

This TMDL uses information from a Habitat Conservation Plan (HCP) prepared by Simpson Timber Company (STC) for more than 80 percent of its Northwest Timberland holdings in the State of Washington. The plan area (about 261,575 acres) includes nearly 1,400 miles of streams that drain STC lands bordering the southern extent of the Olympic Mountains. The largest portion of these lands encompass major northern tributaries to the Chehalis River, including the Satsop and Wynoochee Rivers. A smaller portion includes several Skokomish River tributaries. A final portion includes streams draining to South Puget Sound (i.e. Goldsborough and Kennedy Creeks) and Hood Canal.

As a result of water quality standards (WQS) exceedances for temperature, four waters (Rabbit Creek, Wildcat Creek, Wynoochee River, N.F. Skokomish River) in the HCP area were included on Washington's 1996 §303(d) list. In addition to the listed §303(d) waters, this TMDL also applies to other potential water quality impairments from heat and sediment for all streams within Simpson's HCP area (*Table 1-1*). This expanded coverage is accomplished by using inventory information assembled in development of the HCP.

***Table 1-1.*** Scope of "Simpson HCP Area" TMDL including §303(d) Listed Segments

§303(d) Listed Segments		
Lithotopo Unit	(stream miles)	Applicable Water Quality Standards
Rabbit Creek (mouth to headwaters)		WAC 173-201A-045(1)(c)(iv)***
Wildcat Creek (mouth to headwaters)		WAC 173-201A-045(2)(c)(iv)
Wynoochee River (mouth to headwaters)		WAC 173-201A-045(1)(c)(vii)
N.F. Skokomish River		WAC 173-201A-070(2)
Alpine Glaciated (AGL)	(137.7)	*** WAC 173-201-080 describes the use classifications for waters of the State of Washington.
Crescent Islands (CIS)	(163.7)	
Crescent Uplands (CUP)	(265.2)	
Recessional Outwash Plain (ROP)	(376.7)	
Sedimentary Inner Gorge (SIG)	(454.5)	
<b><u>Note:</u></b> There are nearly 1,400 stream miles that lie within the HCP area. Rather than individually list each stream and segment, information in the TMDL is summarized using either lithotopo units (LTUs), channel types, or Riparian Management Strategies (RMSs) defined in the HCP. There are five LTUs (named above), 49 channel types, and eight RMSs described in the Simpson HCP which apply to all streams in the Plan area (both perennial and intermittent). Principle drainages within the HCP area include:  WRIA 14 = Kennedy - Goldsborough Watershed WRIA 16 = Skokomish River (North & South Forks) 16.0001-0013 WRIA 22 = Chehalis River Basin (lower) including portions of 22.0260-.0290, 22.0291-.0301; Satsop River 22.0360-0464, West, Middle, and East Fork Satsop River, Decker Creek, Wildcat Creek, Wynoochee River		

### Water Quality Impairments

The “Simpson HCP area” TMDL addresses fisheries concerns resulting from impairments due to water temperature increases in several tributaries of the lower Chehalis and Skokomish Rivers. The applicable water quality standard (WQS) states that: *“Temperature shall not exceed 16.0°C (freshwater) or 13.0°C (marine water) due to human activities ... When natural conditions exceed 16.0°C (freshwater) or 13.0°C (marine water), no temperature increase will be allowed which will raise the receiving water temperatures by greater than 0.3°C ... Whenever the natural conditions of said waters are of a lower quality than the criteria assigned, the natural conditions shall constitute the water quality criteria”*.

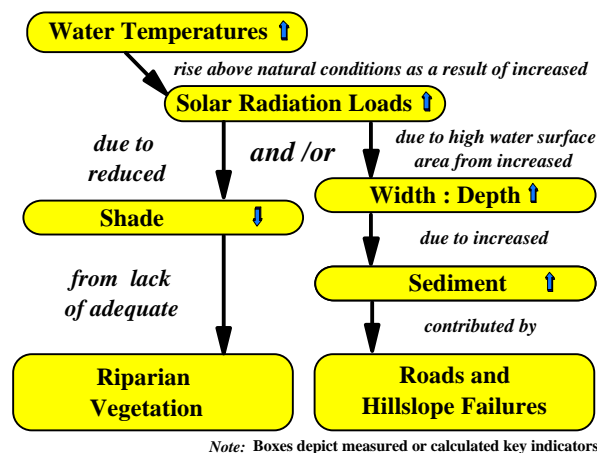
### Pollutants

The “Simpson HCP area” TMDL has been developed for the following pollutants: heat (i.e. incoming solar radiation) and sediment. Both heat and sediment are considered pollutants under CWA §502(6). These pollutants contribute to water temperature increases in two ways. First, heat transfer from excess amounts of solar radiation reaching the stream surface provides energy to raise water temperatures. Second, excessive delivery of sediment increases channel width through deposition and lateral scour. Wider channels then increase the amount of surface area exposed to heat transfer from solar radiation.

### Surrogate Measures

The “Simpson HCP area” TMDL incorporates measures other than “daily loads” to fulfill requirements of §303(d). Although a loading capacity for heat can be derived [e.g. British Thermal Units (BTU) per square foot per day], it is of limited value in guiding management activities needed to solve identified water quality problems. Instead, the “Simpson HCP area” TMDL uses “other appropriate measures” (or surrogates) as provided under EPA regulations [40 CFR §130.2(i)]. The specific surrogates used are percent effective shade and sediment delivery. Decreased effective shade is the result of a lack of adequate riparian vegetation available to block sunlight (i.e. heat from incoming solar radiation). Excessive delivery of sediment is associated with road management and hillslope failures that contribute to channel widening. The relationship of water temperature increases to these surrogates is described in Figure 1-1.

**Figure 1-1.** Relationship of Water Temperature to Surrogates



**Loading Capacity**

Loading capacities in the “*Simpson HCP area*” TMDL address heat from incoming solar radiation (expressed as percent effective shade) and sediment delivery (expressed as average annual cubic yards per lineal stream mile). Analysis of energy transfer processes indicate that water temperatures can increase above natural daily fluctuations at some point when the heat load from solar radiation is greater than the heat leaving the system.

Using information about each channel class (e.g. drainage area, active channel width, range of flows, etc) effective shade targets can be developed. The channel classification system is used to assess stream reaches according to temperature groups, e.g. the dominant control(s) which influence water temperature, specifically shade, groundwater, or channel morphology. This approach leads to effective shade targets which recognize the variability in channel and riparian characteristics that occurs across the landscape. As such, these targets reflect the range of active channel widths and riparian vegetation heights within the HCP area (*Table 1-2*).

**Table 1-2.** Effective Shade Loading Capacity Targets

Active Channel Width <sup>1</sup> (meters)	Vegetation Height <sup>2</sup> (feet)	Effective Shade <sup>3</sup> — <i>by temperature group</i> (%)						
		S-1	S-2	S-3	S-4	G-1	G-2	C-1
≤4	42.3	90	84	84	77		65	
6 - 10	105.7	87	82		76	85	68	89
12 - 15	158.5	89	85			85	68	
16 - 18	170.0			83	81	75		85
20 - 25	170.0						65	76
>25	170.0							72
<sup>1</sup> This table summarizes the effective shade loading capacity targets by active channel width. Active channel width determines the surface area requiring effective shade. The HCP identifies 49 channel classes (summarized in Section 2 of this Technical Assessment) which are used to identify 7 temperature groups. These temperature groups are described in Section 3. Section 6 describes information on active widths associated with each LTU, channel class, and Riparian Management Strategy.  <sup>2</sup> Riparian vegetation height that completely shades a 45° aspect stream at 1pm (daylight time) on June 21.  <sup>3</sup> Effective shade targets calculated using a heat budget for channel types within each temperature group that are needed to achieve a maximum peak hourly increase of 0.45 °C (described in Section 3). This maximum peak hourly increase serves as a numeric interpretation of the narrative criteria for “ <i>natural conditions</i> ”. As new data and methods are developed to better describe “ <i>natural conditions</i> ”, the loading capacities may be refined and the TMDL revised.								

As noted in Table 1-2, the loading capacity targets recognize that during critical periods, natural conditions may exceed the numeric temperature criteria specified in the water quality standards. WAC 173-201A-070(2) states that: “*whenever the natural conditions of said waters are of a lower quality than the criteria assigned, the natural conditions shall constitute the water quality criteria*”. Using data from the Simpson HCP area, a target peak hourly increase is used as an interpretation of the narrative natural conditions clause. This approach incorporates consideration of natural conditions by looking at an increase from a base temperature (as opposed to engaging in a debate about the actual level of that base temperature).

The effect of sediment and its relationship to numeric water quality standards is incorporated into the “*Simpson HCP area*” TMDL through the temperature group approach. One group, *C-1*, represents streams where temperatures are strongly influenced by channel patterns affected by high sediment supply. Development of a loading capacity for sediment considers Washington’s Water Quality Standards which state “*deleterious material concentrations shall be below those which may adversely affect characteristic water uses*”. To maintain a focus on source input and hazard reduction, the loading capacity for sediment uses a framework suggested in the TFW Watershed Analysis Manual, specifically construction of a partial sediment budget (Reid and Dunne, 1996). Erosion processes considered in the partial sediment budget include mass wasting (shallow rapid landslides, debris torrents, large persistent deep-seated landslides), surface erosion, and bank erosion (Table 1-3).

**Table 1-3.** Sediment Loading Capacity by Lithotopo Unit

Lithotopo Unit <sup>1</sup>	Size of HCP Area (%)	Length (miles)	Loading Capacity <sup>2</sup> (yd <sup>3</sup> / stream mile per year)				
			Mass Wasting			Surface Erosion	Bank Erosion
			SR	DT	LPD		
AGL	8	137.7	25	1	15	4	8
CIS	12	163.7	15	1	1	2	4
CUP	11	265.2	35	35	1	3	6
ROP	45	376.7	15	0	1	1	2
SIG	24	454.5	25	1	60	8	10 <sup>a</sup> - 25 <sup>b</sup>
<b>Total</b>	100	1397.8					

**NOTES:**

<sup>1</sup> There are nearly 1,400 stream miles that lie within the HCP area. Rather than individually list each stream and segment, sediment loading capacities are summarized using the lithotopo units (LTUs) described in the HCP. There are five LTUs described in the Simpson HCP which apply to all streams in the Plan area (both perennial and intermittent). Specific streams are defined by LTU / channel class.

<sup>2</sup> Loading capacities expressed as long term annual average values and do not reflect the wide range spatial and temporal variation observed in natural erosion processes. As new data and methods are developed to better describe sediment delivery mechanisms, the loading capacities may be refined and the TMDL revised.

<sup>a</sup> Small channels; <sup>b</sup> Large channels

Sediment delivery targets for this TMDL are expressed in terms cubic yards. This has several advantages which recognize the “*order of magnitude estimate*” that the values actually represent. First, initial calculations of sediment delivery are based on linear or areal estimates of erosion features (e.g. inches per year of bank erosion, feet of soil depth, square yards of landslide feature). Second, weight could be estimated either through assumptions or measurements of the bulk density of soil (e.g. tons per cubic yard). Lastly, cubic yards is more easily related to a wider range of individuals (e.g. a 10 yard<sup>3</sup> dump truck). Loading capacities are summarized by lithotopo unit within the HCP area (*Table 1-3*).

Although an annual averaging period is used to express the loads, it is simply a referencing mechanism. Erosion processes which are responsible for sediment inputs to the system are highly dynamic, change from year-to-year, and vary in different locations in the basin. The sediment assessment used to develop the loading capacity is based primarily on historical data (e.g. landslide inventories), streamflow patterns, and channel responses. It is difficult to predict future erosion and associated effects because of highly variable annual weather patterns and changing management practices. However, the sediment delivery targets define a framework which place erosion processes into the appropriate context relative to the varied lithology and topography of the HCP area.

### Allocations

Allocations in the “*Simpson HCP area*” TMDL are derived using effective shade and sediment delivery targets. These measures can be linked to source areas and, thus to actions (specifically riparian management and erosion control measures) needed to address processes which influence water temperature. Because factors that affect water temperature are interrelated, both measures are dependent upon each other to produce the desired responses.

Effective Shade: The “*Simpson HCP area*” TMDL and allocations for effective shade are summarized in Table 1-4. The objective of the effective shade TMDL is to reduce heat from incoming solar radiation delivered to the water surface. The basis for effective shade allocations results from an analysis of processes that affect water temperature. Development of these effective shade allocations also uses information about riparian management strategies described in the HCP. The analysis of processes that affect water temperature include use of a heat budget and knowledge of riparian shading mechanisms.

Effective shade allocations have been developed from targets based on channel class width and characteristics of mature riparian vegetation for that channel class including vegetative density. Effective shade allocations are a function of the vegetation that will shade the widest active channel for each class. The active channel width, the vegetative density associated with a particular Riparian Conservation Reserve (RCR) width, and the height associated with the expected riparian community (e.g. mixed conifer / hardwood) is used to determine effective shade allocations.

**Table 1-4.** Effective Shade TMDL and Load Allocations Summary for Simpson HCP Area

Segment Name <i>(length in mi.)</i>  <i>Riparian Management Strategy</i>	TMDL	TMDL Components <sup>2</sup> <i>(Effective Shade as percent)</i>		
		WLA	LA	MOS
Rabbit Creek				
Wildcat Creek				
Wynoochee River				
<i>Temperature Sensitive</i> 53.3	88.7%	0%	90.0%	(1.3%)
<i>Break in Slope</i> 171.1	85.4%	0%	91.6%	(6.3%)
<i>Canyon</i> 59.4	68.0%	0%	94.1%	(26.1%)
<i>Channel Migration</i> 83.7	79.7%	0%	84.4%	(4.7%)
<i>Inner Gorge</i> 50.4	70.6%	0%	77.5%	(6.9%)
<i>Alluvial Bedrock Transition</i> 15.6	85.0%	0%	88.4%	(3.4%)
<i>Reverse Break in Slope</i> 42.8	83.9%	0%	95.0%	(11.1%)
<i>Unstable Slopes / Intermittent Flow</i> 921.5	77.0%	0%	93.0%	(16.0%)
<b>TMDL</b>				
<p><b><u>NOTES:</u></b></p> <p><sup>1</sup> Specific streams to which an RMS applies are identified in the HCP and are defined by LTU / channel class. The effective shade TMDL and allocations are designed to achieve a loading capacity that provides sufficient shade needed to minimize water temperature increases. Shade targets developed through use of temperature groups which consider topography, active channel width, groundwater, and potential natural riparian vegetation.</p> <p><sup>2</sup> <b>WLA:</b> Waste load allocation; <b>LA:</b> Load allocation; <b>MOS:</b> Margin of Safety. There are no point sources within the HCP area covered by the TMDL, so the WLA for effective shade is 0.</p>				

**Sediment Delivery:** The “Simpson HCP area” TMDL and allocations for sediment delivery are summarized in Table 1-5. The estimated total allowable sediment load (TMDL) is derived from targets based on lithotopo unit, channel class and erosion process (cubic yards per mile per averaging period). Sediment delivery information for the period 1946-96 was used from three completed Watershed Analysis reports conducted in the Simpson HCP area.

A quantitative comparison of estimated loading rates and controllable portions of various types of loading was considered. The load allocations incorporate sediment reductions from management activities into the sediment delivery targets. Sediment delivered from shallow rapids landslides and debris torrents as a result of management activities is assumed to be 80% controllable. This is based on information used for development of prescriptions in the W.F. Satsop Watershed Analysis. Sediment delivered from large persistent deep-seated landslides as a result of management activities is assumed to be 50% controllable. The retention of large wood in RCRs and reducing peak flows due to hydrologic effects of the road network and forest harvesting will address sediment delivery from bank erosion that have potentially been triggered by management activities.

**Table 1-5.** Sediment Delivery TMDL and Load Allocations Summary for Simpson HCP Area

Riparian Strategy  (length in mi.)	TMDL <sup>1</sup>	WLA <sup>2</sup>	Load Allocations <sup>1</sup> (yd <sup>3</sup> / mile per year)				MOS	
			Mass Wasting			Surface Erosion		Bank Erosion
			SR	DT	LPD			
T.S. 53.3	32.1	0	13.4	0.2	6.8	2.2	4.6	4.9
BIS 171.1	32.8	0	12.6	0.3	7.5	2.1	4.3	6.0
Canyon 59.4	80.0	0	15.0	15.0	1.0	3.0	6.0	40.0
C.M. 83.7	41.5	0	13.3	0.3	11.1	3.3	6.8	6.7
I.G. 50.4	111.5	0	18.6	2.6	40.7	10.1	21.0	18.5
A.B.T. 15.6	96.0	0	20.0	1.0	35.0	8.0	17.0	15.0
R. BIS 42.8	59.9	0	19.2	1.0	18.9	4.8	9.6	6.4
US/IF 921.5	51.0	0	15.5	3.7	9.0	3.3	6.6	12.9
<p><b>NOTES:</b> <sup>1</sup> Allocations expressed as long term annual average values. As new data and methods are developed to better describe sediment delivery mechanisms, the loading capacities may be refined and the TMDL revised.</p> <p><sup>2</sup> There are no point sources within the HCP area covered by the TMDL, so the WLA for sediment delivery is 0.</p>								

The resultant load allocations for sediment are: 1) developed for erosion processes; 2) associated with land use activities where feasible; and 3) based on an assessment of various erosion processes. The load allocations are expressed as long term annual average load delivered per mile at the channel class scale.

### Document Organization

Preparation of the “*Simpson HCP area*” TMDL considered a number of issues regarding surface water temperatures and the relationship to requirements of §303(d). These issues have been divided into topic areas which include target identification (quantified end-points that will lead to attainment of water quality standards), source identification (a description of hazard areas that contribute to the problem), allocations designed to reduce pollutant inputs to those waters exceeding water quality standards, and a margin of safety. In order to provide a framework for discussing these issues, this TMDL development document is organized into the following sections:

- ✓ Target Identification
- ✓ Deviation from Target
- ✓ Source Assessment
- ✓ TMDL / Allocations
- ✓ Margin of Safety
- ✓ Seasonal Variation
- ✓ Implementation and Monitoring

Highlights of each TMDL development document section are summarized in Table 1-6.

**Table 1-6. "Simpson HCP area" TMDL Components**

State/Tribe: <u>Washington</u> Waterbody Name(s): <u>The following §303(d) listed waters: Rabbit Creek, Wildcat Creek, Wynoochee River plus other potential water quality impairments on unlisted streams in the HCP area</u>	
Point Source TMDL: <u>    </u> Nonpoint Source TMDL: <u>X</u> (check one or both) Date: <u>August 26, 1999</u>	
Component	Comments
<b>Loading Capacity</b>           <i>CWA §303(d)(1)</i> <i>40 CFR §130.2(f)</i>	<u><b>Applicable Water Quality Standards</b></u> ! Water temperature shall not exceed 16.0 C due to human activities. No increase allowed that raises water temperatures by more than 0.3 C. [WAC 173-201A-045(1)(c)(iv)]. ! Deleterious material concentrations shall be below those which may adversely affect characteristic water uses ... [WAC 173-201A-045(1)(c)(vii)]. ! Whenever natural conditions are of lower quality than the criteria, natural conditions shall constitute the water quality criteria... [WAC 173-201A-070(2)].  <u><b>Loading Capacities</b></u> ! Reduce incoming solar radiation load by using % effective shade targets. ! Reduce sediment by decreasing road surface erosion and % hillslope failures through sediment delivery targets (yd <sup>3</sup> / mile per year).  These loading capacities are designed to bring water temperatures and sediment regimes to the water quality standards by restoring natural channel conditions.
<b>Existing Sources</b>           <i>CWA §303(d)(1)</i>	Anthropogenic sources of thermal gain result from riparian vegetation removal and delivery of sediment from increased hillslope failures due to: ! Forest management within riparian areas ! Timber harvest in sensitive areas outside the riparian zone ! Roads
<b>Seasonal Variation</b>           <i>CWA §303(d)(1)</i>	<i>Condition:</i> Based on TFW and USGS data. <i>Flow:</i> Low flow associated with maximum water temperature. <i>Critical</i> Maximum temperatures typically occur between mid-July and mid-August. <i>Conditions:</i> Use LTUs / channel classification as analysis framework. Increase riparian vegetation and/or decrease sediment from roads hillslope failures. <i>Inputs:</i> Solar radiation increased by more exposed stream surface area as a result of decreased shade & increased sediment from roads and hillslope failures.
<b>TMDL / Allocations</b>           <i>40 CFR §130.2(g)</i> <i>40 CFR §130.2(h)</i>	<i>WLAs:</i> (No point sources) <i>LAs:</i> Effective shade levels determined by active channel width, riparian vegetation height, and shade quality. Sediment delivery targets determined by lithotopo unit and channel class.
<b>Margin of Safety</b>           <i>CWA §303(d)(1)</i>	! Margin of safety described through documentation of assumptions, e.g. contribution of groundwater, critical conditions. ! Allocations for effective shade contain an explicit margin of safety which is expressed as an unallocated portion of the loading capacity. ! Allocations for effective shade also contain an implicit margin of safety, specifically the point of measurement for Riparian Conservation Reserves.

## 2. WATER QUALITY CONCERNS

The “Simpson HCP area” TMDL is being established for heat and sediment to address fisheries concerns involving impairments due to water temperature increases. The Simpson HCP area includes approximately 261,575 acres of forested watersheds located near Shelton, Washington. Salmon, steelhead, and cutthroat trout occur throughout Simpson HCP area watersheds. Significant fish-bearing streams are the Wynoochee River, the Satsop River including key tributaries (West Fork, Middle Fork, East Fork, Canyon River, Bingham Creek, Stillwater River), the S.F. Skokomish River, and several drainages to South Puget Sound (e.g. Goldsborough Creek, Kennedy Creek).

### Applicable Water Quality Standards

Within the State of Washington, water quality standards are published pursuant to Chapter 90.48 of the Revised Code of Washington (RCW). Authority to adopt rules, regulations, and standards as are necessary and feasible to protect the environment and health of the citizens of the State is vested with the Department of Ecology. Through the adoption of water quality standards, Washington has identified the designated uses to be protected in each of its drainage basins and the criteria necessary to protect these uses [Washington Administrative Code (WAC), Chapter 173-201].

In Washington, “*specific fresh waters of the state of Washington are classified ...*” [WAC 173-201-080]. The Simpson HCP area lies within the Satsop (East Fork, Middle Fork, West Fork), Skokomish, and Wynoochee drainages. WAC 173-201-080 identifies these watersheds as class “AA”. Water quality standards not to be exceeded are described in WAC 173-201-045. For “AA” streams:

*“Temperature shall not exceed 16.0°C (freshwater) or 13.0°C (marine water) due to human activities. ... When natural conditions exceed 16.0°C (freshwater) or 13.0°C (marine water), no temperature increase will be allowed which will raise the receiving water temperatures by greater than 0.3°C”*  
[WAC 173-201A-045(1)(c)(iv)].

For “A” streams:

*“Temperature shall not exceed 18.0°C (freshwater) or 16.0°C (marine water) due to human activities. ... When natural conditions exceed 18.0°C (freshwater) or 16.0°C (marine water), no temperature increase will be allowed which will raise the receiving water temperatures by greater than 0.3°C”*  
[WAC 173-201A-045(2)(c)(iv)].

The applicable water quality standard for sediment states:

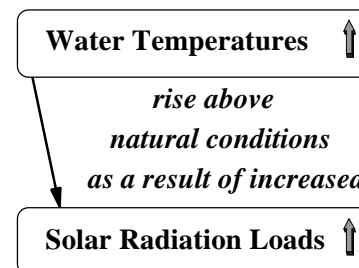
*“deleterious material concentrations shall be below those which may adversely affect characteristic water uses ...”*  
[WAC 173-201A-045(1)(c)(vii)].

Finally, during critical periods, natural conditions may exceed the numeric criteria for temperature identified in the water quality standards. In these cases, the following applies:

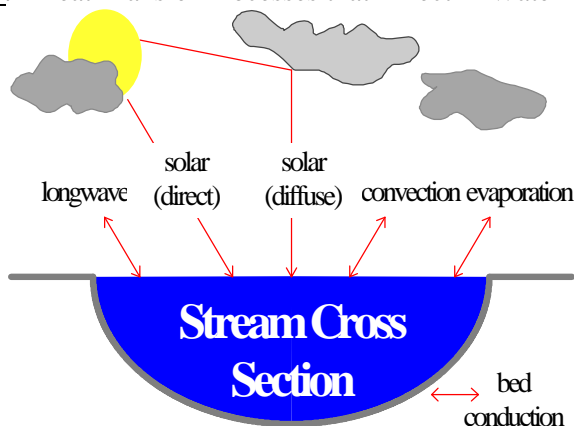
*“Whenever the natural conditions of said waters are of a lower quality than the criteria assigned, the natural conditions shall constitute the water quality criteria”* [WAC 173-201A-070(2)].

### Water Temperature and Solar Radiation

Stream temperature is an expression of heat energy per unit volume, or an indicator of the rate of heat exchange between a stream and its environment (*Figure 2-1*). In terms of water temperature increases, the principle source of heat energy is solar radiation directly striking the stream surface (Brown, 1970). Energy is acquired by a stream system when the heat entering the stream is greater than the heat leaving the stream. When there is a net addition of heat energy to the stream, the water temperature will increase.



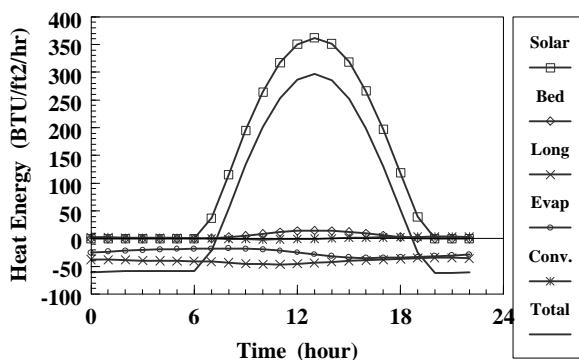
**Figure 2-1.** Heat Transfer Processes that Affect in Water Temperature



As discussed in other studies (Brown 1969, Beschta et al 1987), the daily profile for water temperature increases typically follows the same pattern of solar radiation delivered to an unshaded stream (*Figure 2-2*). Other processes, such as longwave radiation and convection also introduce energy into the stream, but at much smaller amounts when compared to solar radiation. If a stream is completely unshaded, as is the case in Figure 2-2, the solar radiation flux has the potential to deliver large quantities of heat energy, resulting in a rapid increase in water temperature.

**Figure 2-2.** Typical Summer Energy Balance for an Unshaded Stream

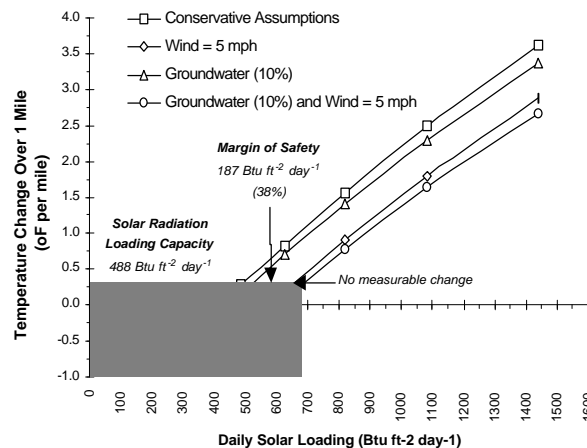
#### Typical Summer Energy Balance (Unshaded Stream -- July 15)



Mechanistic models have been developed based on a heat budget approach which estimate water temperature under different heat balance and flow conditions. Brown (1969) was the first to apply a heat budget to estimate water temperatures on small streams affected by timber harvest. This heat budget technique utilizes six variables (solar radiation, long wave radiation, evaporation, convection, bed conduction, and advection) to determine the net gain or loss of stored heat ( $H$ ) in a known volume of water. This change in  $H$  can then be converted to a temperature change. Using mathematical relationships to describe heat transfer processes, the rate of change in water temperature on a summer day can be estimated. Relationships include both the total energy transfer rate to the stream (i.e. the sum of individual processes) and the response of water temperature to heat energy absorbed. Heat transfer processes considered in the analysis include solar radiation, longwave radiation, convection, evaporation, and bed conduction (Wunderlich 1972, Jobson and Keefer 1979, Beschta and Weathered 1984, Sinokrot and Stefan 1993).

Figure 2-2 shows that solar radiation is the predominant energy transfer process which contributes to water temperature increases. A general relationship between solar radiation loads and stream temperature can be developed by quantifying heat transfer processes (*Figure 2-3*). In this example, average unit solar radiation loads greater than 675 BTU / ft<sup>2</sup> per day result in a noticeable increase in water temperature. This could represent a starting point to define a loading capacity (i.e. the greatest amount of loading that a water can receive without violating water quality standards).

**Figure 2-3.** General Relationship between Solar Radiation Loads and Water Temperature



**Explanation:**

Figure 2-3 describes the relationship between solar radiation load and water temperature change. The response of water temperature to solar radiation loads was determined by evaluating the sum of individual heat transfer processes, or:

$$\Phi_{\text{total}} = \Phi_{\text{solar}} + \Phi_{\text{longwave}} + \Phi_{\text{evaporation}} + \Phi_{\text{convection}} + \Phi_{\text{conduction}}$$

Individual heat transfer rates were estimated using the location of the Simpson HCP area (i.e. same latitude / longitude range) and conservative assumptions. The graph contains four curves representing different assumptions on groundwater inflow and wind speed.

### Surrogate Measures

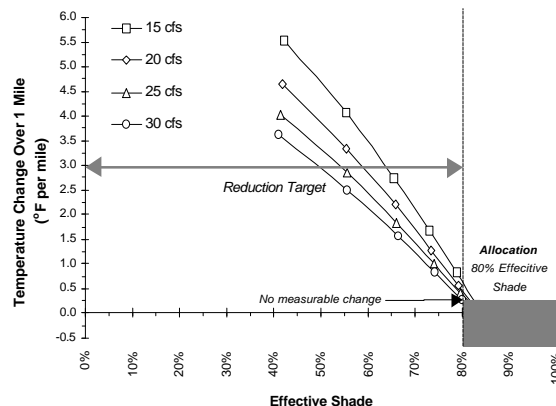
The “Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program” (FACA Report, July 1998) offers a discussion on the use of surrogate measures for TMDL development. The FACA Report indicates:

*“When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where the impairment is identified but cannot be attributed to a single traditional “pollutant,” the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not. The criterion must be designed to meet water quality standards, including the waterbody’s designated uses. The use of BPJ does not imply lack of rigor; it should make use of the “best” scientific information available, and should be conducted by “professionals.” When BPJ is used, care should be taken to document all assumptions, and BPJ-based decisions should be clearly explained to the public at the earliest possible stage.*

*If they are used, surrogate environmental indicators should be clearly related to the water quality standard that the TMDL is designed to achieve. Use of a surrogate environmental parameter should require additional post-implementation verification that attainment of the surrogate parameter results in elimination of the impairment. If not, a procedure should be in place to modify the surrogate parameter or to select a different or additional surrogate parameter and to impose additional remedial measures to eliminate the impairment.”*

The “Simpson HCP area” TMDL utilizes measures other than “daily loads” to fulfill requirements of §303(d). Although a loading capacity for heat can be derived [e.g. BTU/ft<sup>2</sup> per day], it is of limited value in guiding management activities needed to solve identified water quality problems. The concept regarding the effect of solar radiation loads on stream temperatures is illustrated in Figure 2-4. Information is presented in terms of the percent reduction of potential daily solar radiation load delivered to the water surface. This provides an alternative target (or “other appropriate measure”) which relates to stream temperatures, in this case, an 80% reduction in potential solar radiation delivered to the water surface. Thus, as an alternative, the “Simpson HCP area” TMDL uses “other appropriate measures” (or surrogates) as provided under EPA regulations [40 CFR §130.2(i)].

**Figure 2-4.** Effect of Solar Radiation Reduction (Effective Shade) on Water Temperature



### Watershed / Landscape Scale Analyses

TMDL development for nonpoint sources presents some inherent challenges. Diffuse sources are often associated with watershed or landscape scale features. Consequently, water quality concerns associated with nonpoint source (NPS) pollutants require a different approach from traditional point source problems. The “Simpson HCP area” TMDL employs several concepts applied at a broader scale. These watershed / landscape scale concepts are evaluated in order to determine the best targets for the “Simpson HCP area” TMDL. Watershed / landscape scale concepts used to organize the target identification include:

- ! Landscape stratification
- ! Channel classification

Landscape Stratification: The foundation of the proposed HCP lies within the system Simpson has developed to better understand the inherent characteristics and sensitivities of their lands, and how their long-term forest management plans interact with these features. The proposed HCP notes that “...at a fundamental level, ecosystem structure and dynamics are influenced by geological settings, climatic factors and their interaction. Any site specific, science-based approach to landscape planning must account for these essential influences because they are largely responsible for much of the natural variation in habitat types at various spatial and temporal scales”.

Influences of geologic setting and associated physical processes within the HCP area are captured by stratifying the landscape into “*lithotopo*” units (LTU), i.e. areas of similar lithology and topography. LTU boundaries are determined by geology, geological history, and topographic relief. This approach divides Simpson’s HCP area into units that share similar erosion and channel forming processes. LTUs include:

- ! Alpine glacial (AGL)
- ! Crescent islands (CIS)
- ! Crescent uplands (CUP)
- ! Recessional outwash plain (ROP)
- ! Sedimentary inner gorges (SIG)

Channel Classification: Conditions in a waterbody are a function of channel morphology (e.g. source, transport, or response reaches). Methods exist to assess the condition of a stream, as well as departure from its potential (Rosgen, 1996). These methods, built around channel classification, are a useful starting point to develop specific TMDL surrogate measures for streams in the Simpson HCP area. Consequently, a second lower level of stratification consists of classifying stream segments of the channel network within each of the LTU.

There are 49 individual stream segment types within this system (*Table 2-1*). Riparian management strategies are keyed to each of the stream types. A description of these can be found within the HCP document. Additional details on channel characteristics, geology, morphology, large woody debris (LWD) characteristics and recruitment processes, sediment delivery and processing mechanisms, riparian characteristics and biological community features are described in HCP appendices. Information on the linkage to instream biological resources is also provided. The small intermittent streams (of varying type) are often quite unstable and if not properly protected may account for substantial inputs of sediments triggered by management activities. The HCP defines which types these are and describes what protective measures will be taken to address the risks they pose.

***Table 2-1a.*** Simpson HCP Area Channel Classes

<b>Lithotopo Unit</b>	<b>Channel Class</b>	<b>Stream Miles</b>	<b>Riparian Management Strategy</b>	<b>Streams</b>
<b>AGL</b>	Qa6	12.7	Channel Migration	Wynoochee
	Qo1	61.3	Unstable / Intermittent	
	Qo2	22.5	Unstable / Intermittent	
	Qo3	7.3	Break in Slope	
	Qo4	2.6	Reverse Break in Slope	
	Qo5	8.8	Break in Slope	
	Qo6	13.6	Break in Slope	Schafer
	Qo7	3.7	Break in Slope	Schafer
	Qo8	5.2	Inner Gorge	Wynoochee
<b>CIS</b>	C1	83.9	Unstable / Intermittent	
	C5	1.7	Reverse Break in Slope	Rock
	Qc1	33.3	Unstable / Intermittent	
	Qc2	28.0	Unstable / Intermittent	
	Qc3	16.8	Channel Migration	Kennedy
<b>CUP</b>	C1	199.9	Unstable / Intermittent	
	C2	22.9	Canyon	
	C3	24.5	Canyon	
	C4	4.9	Canyon	North Mountain
	C5	3.5	Canyon	Dry Bed
	C6	3.6	Canyon	Baker
	C8	5.9	Inner Gorge	Middle Fork Satsop
<b>ROP</b>	C7	9.4	Channel Migration	North Mountain
	Qa7	3.7	Channel Migration	Vance
	Qc1	167.3	Unstable / Intermittent	
	Qc2	103.4	Break in Slope	

**Table 2-1b.** Simpson HCP Area Channel Classes

<b>Lithotopo Unit</b>	<b>Channel Class</b>	<b>Stream Miles</b>	<b>Riparian Management Strategy</b>	<b>Streams</b>
<b>ROP</b>	Qc3	44.2	Temperature Sensitive	Glenn
	Qc4	9.1	Break in Slope	
	Qc5	12.1	Break in Slope	Bingham
	Qc6	9.5	Channel Migration	Decker
	Qc7	15.2	Channel Migration	Stillwater
	Qc8	2.8	Channel Migration	East Fork Satsop
<b>SIG</b>	L1	160.0	Unstable / Intermittent	
	L2	38.5	Reverse Break in Slope	
	L3	6.3	Break in Slope	
	L4	24.2	Inner Gorge	West Fork Satsop
	M1	67.8	Unstable / Intermittent	
	M2	18.5	Unstable / Intermittent	
	M3	9.6	Alluvial / bedrock	
	M4	6.0	Alluvial / bedrock	Sandstone
	M5	15.1	Inner Gorge	Canyon
	M6	2.3	Channel Migration	Cook
	Qa6	11.3	Channel Migration	West Fork Satsop
	Qc1	12.8	Unstable / Intermittent	
	Qc2	8.9	Unstable / Intermittent	
	Qc3	9.1	Temperature Sensitive	
	Qo1	38.3	Unstable / Intermittent	North Fork Abyss
	Qo2	19.0	Unstable / Intermittent	
	Qo3	4.8	Break in Slope	
	Qo4	2.0	Break in Slope	Devils Club

### 3. TARGET IDENTIFICATION

#### Loading Capacity

*Regulatory Framework:* Under the current regulatory framework for development of TMDLs, identification of the loading capacity is an important first step. The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring a water into compliance with standards. By definition, TMDLs are the sum of the allocations [40 CFR §130.2(i)]. Allocations are defined as the portion of a receiving water's loading capacity that is allocated to point or nonpoint sources and natural background. EPA's current regulation defines loading capacity as "the greatest amount of loading that a water can receive without violating water quality standards".

*Mechanistic Models:* A loading capacity for heat (expressed as BTU/ft<sup>2</sup> per day) can be derived using mechanistic models. One of the most basic forms of these models is the fundamental equation applied by Brown (1969) for forest streams (Table 3-1).

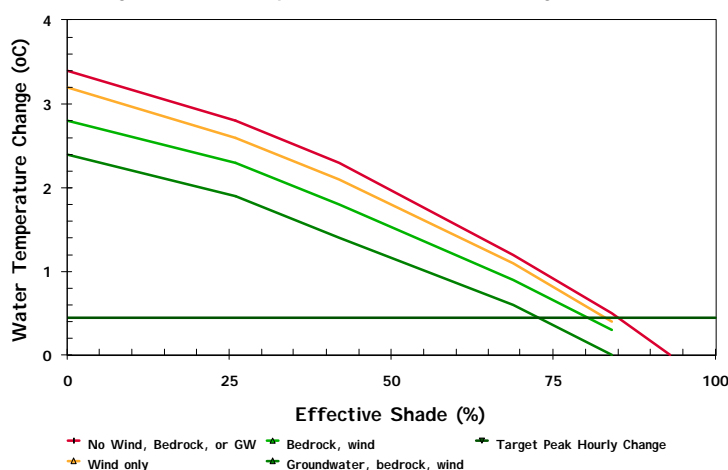
**Table 3-1.** Mathematical Relationship between Water Temperature and Heat

$T = H * A / (V * \rho * c_p)$	
where:	
T =	temperature change ( F / hour)
H =	rate that heat received (BTU / hour)
A =	surface area (ft <sup>2</sup> )
V =	volume (ft <sup>3</sup> )
	= density of water (62.4 lb / ft <sup>3</sup> )
c <sub>p</sub> =	specific heat of water (BTU/ lb / F)

The calculation of water temperature by a mechanistic model follows the basic relationship described in Table 3-1. A mechanistic model is essentially a bookkeeping of heat transfer to determine potential water temperature changes. Using such an approach, a family of curves can be developed which describes different H values designed to achieve a known temperature change. Figure 3-1 illustrates one such set of curves for a class of streams in the Simpson HCP area.

A drawback to the use of mechanistic models, however, is the difficulty in determining solar radiation loads over each stream mile of a large watershed. The curves that result from numerical calculations are influenced by a number of factors. These include stream flow, channel width, upstream water temperature, wind speed, relative humidity, stream bed composition, and groundwater contribution. Higher stream flows, for example, result in higher allowable solar radiation loads when width:depth ratios are held constant. Likewise, narrower channels result in higher allowable loads when stream flows are held constant.

**Figure 3-1.** Simpson HCP Area Pool Riffle Channels  
**Effective Shade and Temperature Change**  
 (using different assumptions on wind, bedrock, and groundwater)



**Natural Conditions:** One complication in using mechanistic models to develop allowable loads is that the result may be the identification of loading capacities that are not achievable. This occurs when the vegetative height associated with a mature riparian forest is not tall enough to shade the entire active channel. For instance, on June 21 the shadow length of a 170 foot tall Douglas fir at 1pm (daylight time) is about 75 feet. This means that an active channel wider than 75 feet will not be completely shaded on that date. For such cases and for cases where the numeric criteria is naturally exceeded, the natural conditions clause of Washington’s water quality standards is applied [WAC 173-201A-070(2)]. This means that where mature riparian vegetation will not fully shade the active channel, the temperature which results from shade achievable by a mature riparian forest becomes the standard. The loading capacity is then the solar load associated with these natural conditions.

To better quantify the linkage between solar loads associated with the natural conditions and the anticipated effect on water temperature, a discussion of diurnal variation is helpful. Diurnal variation in water temperature occurs naturally in stream systems. The magnitude of the temperature change (both diurnal range and peak hourly increase) has greater meaning in TMDL development for nonpoint sources than a “no threshold” criteria (e.g. 16 °C). This is because a TMDL is designed to decrease the pollutant load. Assessing the peak hourly change as a result of load reduction is much more straightforward than predicting attainment of an absolute water temperature. This approach incorporates consideration of natural conditions by looking at the increase from a base temperature (as opposed to engaging in a debate about the actual level of the base temperature).

For instance, water temperatures observed at a site located in a wilderness area situated in an old growth forest (basically natural conditions) might exceed the State criteria of 16 °C on a day when air temperatures reach 100 °F. It would be nearly impossible to develop a TMDL for that stream which guarantees attainment of the 16 °C water quality standard for “AA” waters. The only way to provide that assurance would be to first complete a site specific criteria modification in support of a more appropriate water quality standard. In the absence of a site specific criteria modification, the TMDL is developed by stratifying the landscape into temperature groups. From this framework, effective shade targets are identified for channel types within each temperature group that are needed to achieve a maximum peak hourly increase.

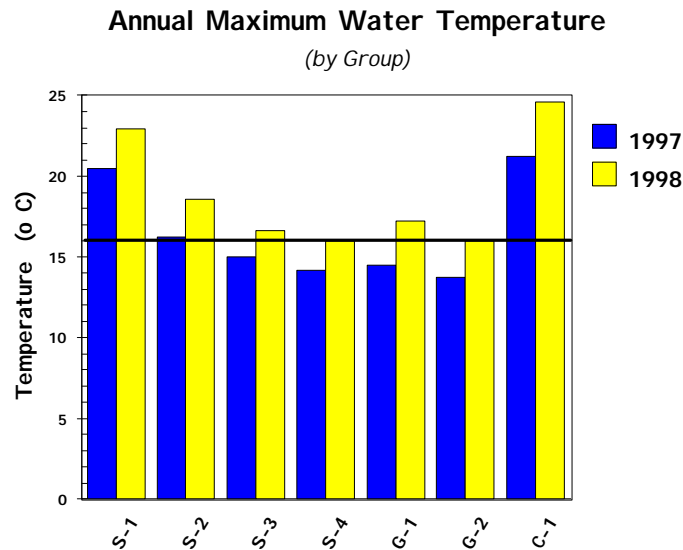
**Temperature Groups:** Using information about each stream type (e.g. the range of stream flows, active channel widths, etc), effective shade targets can be developed for each class of streams. The channel classification system is used to group stream reaches by the dominant control(s) which affect water temperature. Table 3-2 identifies seven groups and describes watershed process features which exert the greatest influence on water temperature in those channel classes. Dominant features include shade, groundwater, and channel morphology.

***Table 3-2. Groups for Identifying Targets to Address Water Temperature***

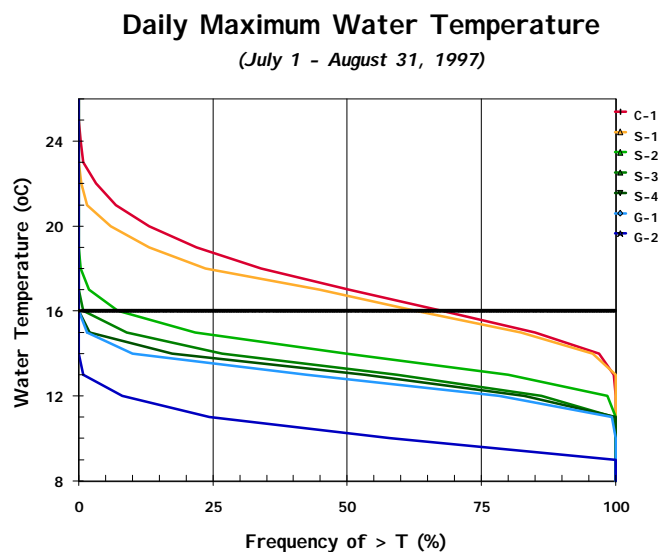
<b>Group</b>	<b>Features</b>	<b>Channel</b>
<b><i>Shade</i></b>		
S-1	Small to medium sized pool riffle and forced pool riffle / plane bed channels of the ROP and SIG. Water temperature is driven by shade and low flows (poor water storage in these watersheds over glacial tills and shallow soils). Headwaters of these systems are usually in wetlands or bogs and beavers frequently pond water within the channel. <i>RMS: Temperature Sensitive.</i>	ROP-Qc1, -Qc2 ROP-Qc3 SIG-Qc3
S-2	Small to medium sized channels in the AGL and SIG. These systems most often have hardwood dominated riparian systems and subtle groundwater influence through wet side slopes. They are subject to heating with the loss of riparian shade which can happen through damage to riparian leave areas by natural factors or through insufficient leave area. <i>RMS: Alluvial Bedrock Transition or Reverse Break in Slope.</i>	AGL-Qo2, -Qo4 SIG-L1, -L2, -L3 SIG-M1, -M2, -M3 SIG-M4, -M6 SIG-Qo2
S-3	Small to medium sized streams in the recessional outwash sediments of the CIS and SIG. These channels have low summer flows, but the storage and character of the flows is different from the ROP in that lower terraces, floodplains, and valley walls of these systems are composed of fine, but fairly well draining unconsolidated outwash sediments. These materials do not store great quantities of water. However, there is a slow release of groundwater that appears to moderate temperatures, but it is not sufficient to offset heating as a result of riparian canopy loss. With loss of shade, these streams can heat up to moderate levels. <i>RMS: Channel Migration or Unstable Slopes / Intermittent.</i>	CIS-Qc1, -Qc2 CIS-Qc3 SIG-Qc1, -Qc2
S-4	Small to medium sized channels in glacial till landscape of the AGL and SIG with pool riffle and forced pool riffle / plane beds. These systems have moderate to low flows in summer with varying amounts of groundwater influence. Along the continuum, those with minimal groundwater influence are susceptible to elevated water temperatures with loss of shade. Those with significant amounts of groundwater influence are resistant to temperature changes. <i>RMS: Break in Slope.</i>	AGL-Qo3, -Qo5 AGL-Qo6, -Qo7 SIG-Qo3, -Qo4
<b><i>Groundwater</i></b>		
G-1	Small to medium sized pool riffle and forced pool riffle / plane bed channels of the CIS and ROP that are strongly influenced by groundwater. These systems are resistant to changes to water temperature because flow is strong and comes from a cool source. Shade is a secondary influence, except during extreme low flow years. <i>RMS: Channel Migration.</i>	CIS-C5 ROP-Qc4, -Qc5 ROP-Qc6, -Qc7
G-2	Small to medium sized highly confined channels of the AGL, CIS, CUP, and SIG. These are topographically shaded and are "near" the water source with substantial groundwater influence which shows as side seeps and springs. These systems are typically cool and are resistant to water temperature changes, even in the absence of riparian vegetation. <i>RMS: Canyon.</i>	AGL-Qo1, -Qo8 CIS-C1 CUP-C1, -C2, -C3 CUP-C4, -C5, -C6 CUP-C8 SIG-Qo1
<b><i>Channel Morphology</i></b>		
C-1	Large rivers of the AGL, ROP, and SIG are affected by high sediment supply and multiple thread channels over at least some of their length. Applies to the West and Middle Forks of the Satsop, the Canyon, Little and Wynoochee Rivers. Temperatures in these systems are strongly influenced by channel pattern and open canopies. Current and past sediment supply, long residence times, and channel pattern make it unlikely that water temperatures here will change for decades. <i>RMS: Inner Gorge or Channel Migration.</i>	AGL-Qa6 ROP-C7, -Qa7 ROP-Qc8 SIG-L4, -M5, -Qa6

These seven temperature groups allow refinement of assumptions used to develop effective shade targets. Development of effective shade targets is based on a better description of site specific conditions. In addition, actual data collected on streams in the Simpson HCP area is used to validate anticipated responses. Figure 3-2 depicts information collected in 1997 and 1998 from sites representative of each temperature group. Maximum observations between July 1 and August 31 are shown for each year. This corresponds with the seasonal time frame when maximum water temperatures occur. Figure 3-3 illustrates temperature group patterns by showing the difference in cumulative frequency distribution at several sites. Figure 3-4 shows the percentage of streams in the Simpson HCP area that lie within each temperature group. Figure 3-4 also show the percentage of time that the 16 °C was exceeded at each site used to represent the temperature group.

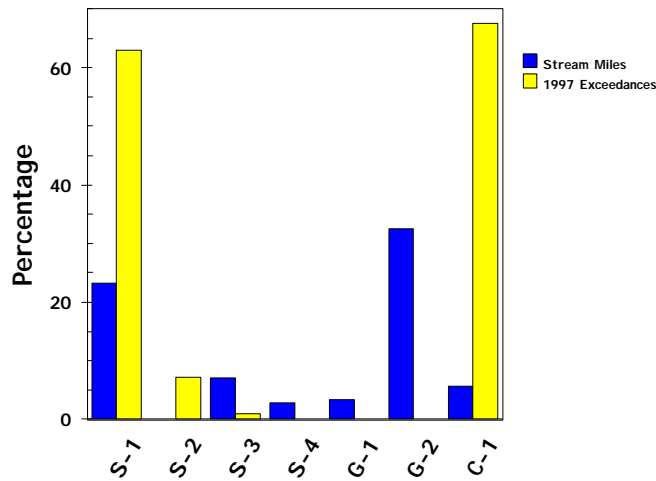
**Figure 3-2.** Annual Maximum Water Temperature by Group



**Figure 3-3.** Comparison of Cumulative Frequency Distribution by Temperature Group

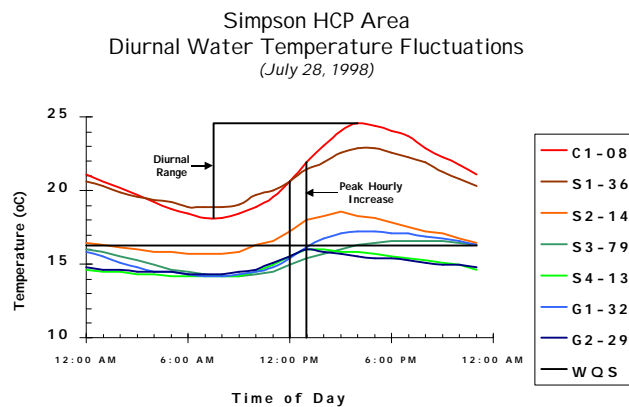


**Figure 3-4.** Distribution of Temperature Groups  
Temperature Group Distribution



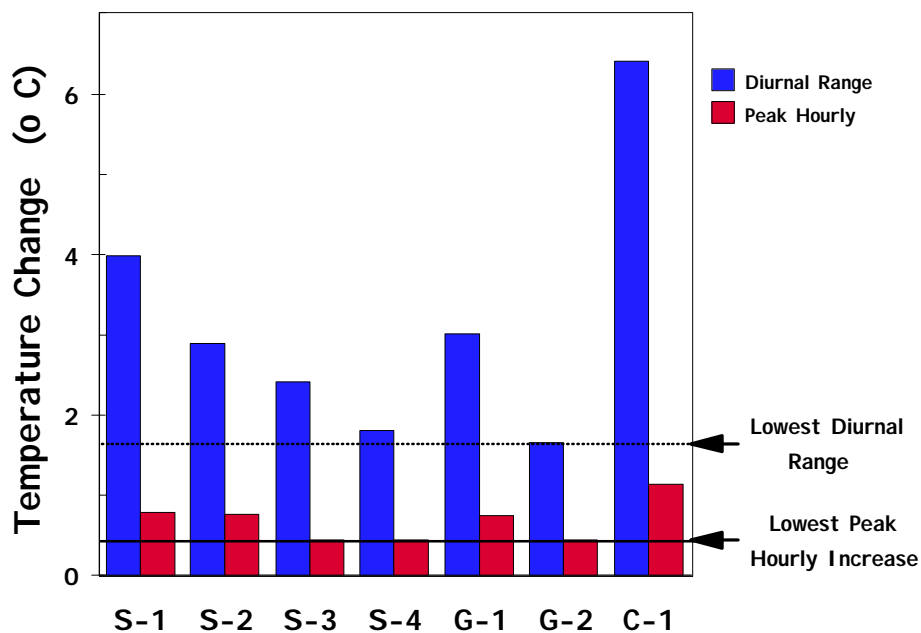
**Peak Hourly Change.** Development of a TMDL (e.g. loading capacity and allocations) which focus on either maximum diurnal range or peak hourly water temperature increase is possible. An analysis can be constructed which evaluates solar radiation inputs and resultant water temperature change through a heat budget analysis. Figure 3-5 depicts the diurnal variation of the temperature group monitoring sites on July 28, 1998. This is the day when maximum water temperatures were observed over the 2-year period for monitoring data provided by Simpson. This also corresponds to the date when the maximum water temperature was observed by the U.S. Forest Service over a 5-year period in the Humptulips watershed (immediately west of the Simpson HCP area). Figure 3-6 shows both the diurnal change and peak hourly water temperature increase for each temperature group. Figure 3-7 shows the relationship between peak hourly increase and daily maximum water temperature. Based on this relationship, the lowest peak hourly increase observed (0.45 °C) is used to derive effective shade targets.

**Figure 3-5.** Temperature Group Summary

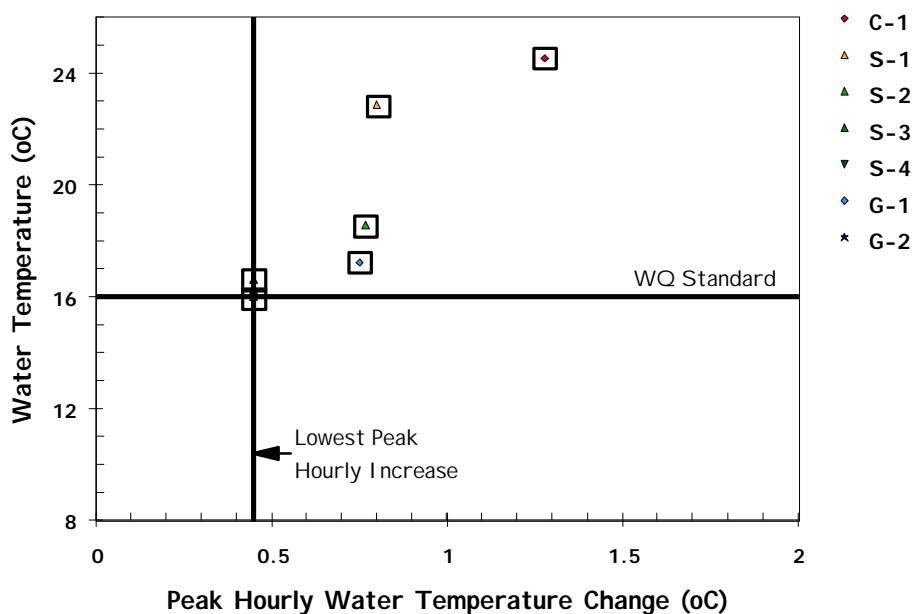


Simpson Data: 7/1/98 - 8/31/98

**Figure 3-6.** Temperature Group Summary  
Temperature change at selected sites  
(July 28, 1998)

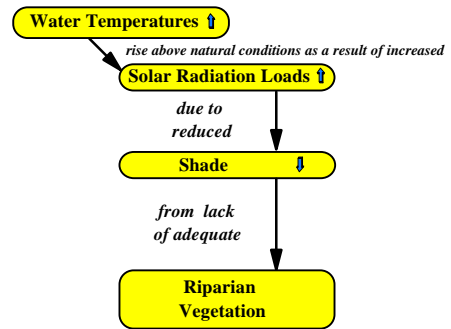


**Figure 3-7.** Temperature Group Summary  
Relationship between Peak Hourly Increase and Daily Maximum Temperature  
(July 28, 1998)

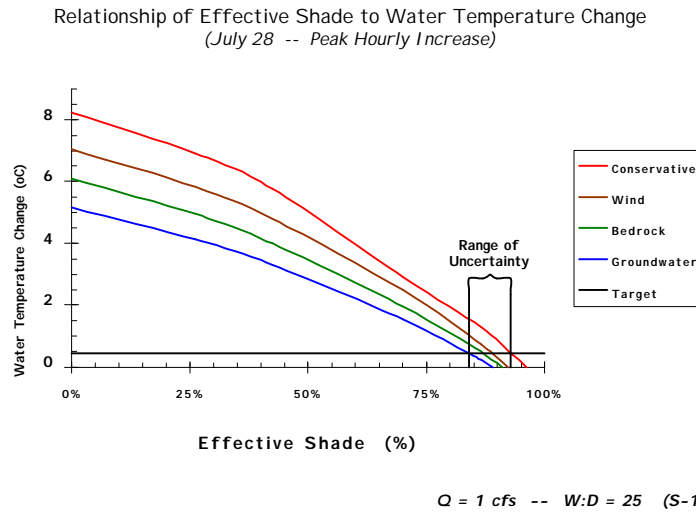


### Development of Targets

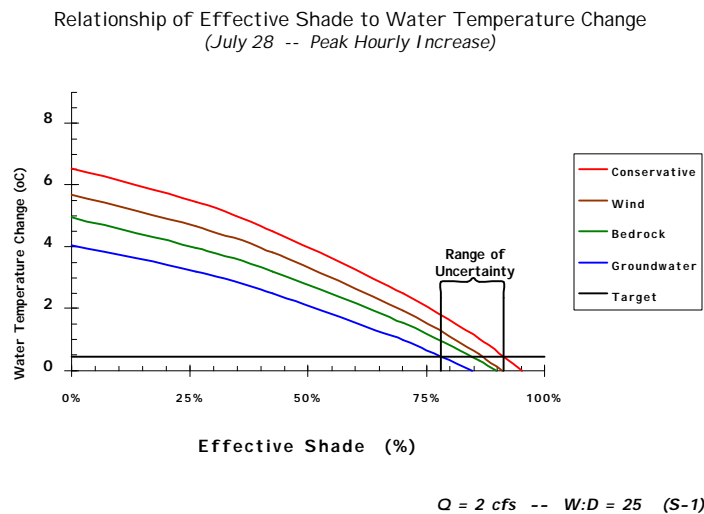
**Effective Shade.** Figure 3-8 shows the theoretical relationship between effective shade and peak hourly water temperature change for small channels ( $ACW \leq 4m$ ) in the ROP. The relationship is based on a heat budget analysis using a range of assumptions (e.g. wind speed, stream bed composition, groundwater contribution,) that probably reflect these types of channels within the S-1 group. Figure 3-9 shows a similar relationship for medium channels in the SIG within the S-1 group. As discussed earlier, a heat budget is useful to show general relationships, but not as an absolute predictor due to the high degree of uncertainty with assumptions.



**Figure 3-8.** Target Development: Group S-1 Small Streams



**Figure 3-9.** Target Development: Group S-1 Medium Stream (SIG)

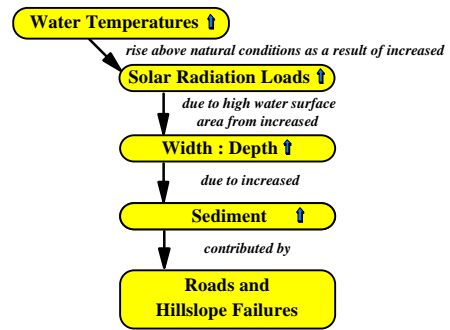


Using information about each channel class (e.g. drainage area, range of flows, etc) effective shade targets can be developed. The channel classification system is used to assess stream reaches according to temperature groups. This approach leads to effective shade targets which recognize the variability in channel and riparian characteristics that occurs across the landscape. As such, these targets reflect the range of active channel widths and riparian vegetation heights by LTU within the HCP area (*Table 3-2*).

***Table 3-2.*** Effective Shade Loading Capacity Targets

Active Channel Width <sup>1</sup> (meters)	Vegetation Height <sup>2</sup> (feet)	Effective Shade <sup>3</sup> — by temperature group (%)						
		C-1	G-1	G-2	S-1	S-2	S-3	S-4
2	21.1			68-CU		82-AG 84-SI		
4	42.3			51-AG 71-CI 68-CU 56-SI	90-RO	84-SI	85-CI 80-SI	76-AG 78-SI
6	63.4		85-CI 85-RO	68-CU		82-AG		
8	84.6	89-RO		68-CU				76-AG
10	105.7				87-SI			
12	126.8		75-RO	68-CU	89-RO	85-SI		
15	158.5		75-RO					
16	169.2	86-RO					87-CI	80-AG 82-SI
18	170.0		75-RO					
20	170.0	72-SI		72-CU				
25	170.0	77-AG 83-RO 77-SI		58-AG				
35	170.0	72-SI						
<sup>1</sup> This table summarizes the effective shade loading capacity targets by active channel width. Active channel width determines the surface area requiring effective shade.  <sup>2</sup> Riparian vegetation height that completely shades a 45° aspect stream at 1pm (daylight time) on 6/21.  <sup>3</sup> Effective shade targets calculated using a heat budget for channel types within each temperature group that are needed to achieve a maximum peak hourly increase of 0.45° C. This maximum peak hourly increase serves as a numeric interpretation of the narrative criteria for "natural conditions". As new data and methods are developed to better describe "natural conditions", the loading capacities may be refined and the TMDL revised.								

***Sediment Delivery:*** The effect of sediment and its relationship to numeric water quality standards is incorporated into the “*Simpson HCP area TMDL*” through a temperature group approach. Groups are defined according to the dominant control(s) which influence water temperature, specifically shade, groundwater, or channel morphology. *Group C-1* represents streams where temperatures are strongly influenced by channel patterns affected by high sediment supply. Changes in sediment input can lead to an alteration of channel form (Leopold et al, 1964; Megahan et al, 1980) through deposition and lateral scour. Water temperatures for *Group C-1* streams are among the warmest monitored.



When delivery of sediment increases over the transport capability of the stream, deposition occurs. Water quality and associated beneficial uses can be affected by deposition of sediment. Within the Simpson HCP area, large rivers of the AGL, ROP, and SIG are affected by high sediment supply and multiple thread channels over at least some of their length. Temperatures in these systems are strongly influenced by channel pattern and open canopies. Deposition of sediment can result in channel filling which leads to increases in channel width. An increase in channel width will increase the amount of solar radiation entering a stream. A wide, shallow will heat up faster than a narrow, deeper stream with the same discharge (Brown, 1972). During storm events, management related sources can increase sediment inputs over background. This contributes to channel widening and stream temperature increases.

Development of a loading capacity for sediment considers Washington’s Water Quality Standards which state “*deleterious material concentrations shall be below those which may adversely affect characteristics water uses*”. The approach includes:

- ☞ Focus on up-slope sediment source targets rather than looking exclusively at the suite of instream features that reflect the outcome of both natural and management related factors.
- ☞ Establish quantifiable targets for sediment delivery by erosion process (e.g. cubic yards delivered per mile per averaging period) associated with each channel class.

***Up-slope sediment source targets*** are included because focusing on instream indicators would not achieve water quality improvements. Hillslope targets supplement instream criteria by providing measurable goals that are not subject to the variability of climatic conditions. Hillslope and road-related targets are easier to measure and are more controllable. Hillslope and road-related targets also have the advantage to a landowner of being easily converted to implementation plans and management practices that can be evaluated more frequently than instream targets. In addition, including these targets address the problem of instream indicators which suggest that conditions are good, while hillslope conditions of sediment to be delivered in the next large storm event continue to pose potential delivery hazards. In short, without addressing hillslope sources, the cycle of degradation could potentially be repeated until some species of aquatic life could no longer recover.

**Quantifiable targets for sediment delivery** enable a focus on source input and hazard reduction. Sediment delivery targets for this TMDL are expressed in terms of cubic yards. This has several advantages which recognize the “*order of magnitude estimate*” that the values actually represent. First, initial calculations of sediment delivery are based on linear or areal estimates of erosion features (e.g. inches per year of bank erosion, feet of soil depth, square yards of landslide feature). Second, weight could be estimated either through assumptions or measurements of the bulk density of soil (e.g. tons per cubic yard). Lastly, cubic yards is more easily related to a wider range of individuals (e.g. a 10 yard<sup>3</sup> dump truck). Development of sediment delivery targets, i.e. the loading capacity, uses a framework suggested in the TFW Watershed Analysis Manual, specifically construction of a partial sediment budget (Reid and Dunne, 1996). This serves several purposes including:

- ☞ tie sediment problems recognized in streams to specific hillslope sources or activities;
- ☞ discriminate among the rates, effects, and hazards of various mass wasting, surface, and bank erosion processes in basins where all are significant sediment sources; and
- ☞ document the relative contributions of sediment delivery processes (e.g. road surface versus deep seated landslides).

Erosion processes considered in the partial sediment budget include mass wasting (shallow rapid landslides, debris torrents, large persistent deep-seated slides), surface erosion, and bank erosion. Sediment delivery targets are based on information contained in three completed Watershed Analysis reports conducted in the Simpson HCP area (W.F. Satsop, S.F. Skokomish, Kennedy Creek). Included is landslide inventory data developed from air photos between 1946 - 96 described in the assessment reports. Loading capacities are summarized by lithotopo unit within the HCP area (*Table 3-3*).

**Table 3-3.** Sediment Loading Capacity by Lithotopo Unit

Lithotopo Unit	Size of HCP Area (%)	Length (miles)	Loading Capacity (yd <sup>3</sup> / stream mile per year)				
			Mass Wasting			Surface Erosion	Bank Erosion
			SR	DT	LPD		
AGL	8	137.7	25	1	15	4	8
CIS	12	163.7	15	1	1	2	4
CUP	11	265.2	35	35	1	3	6
ROP	45	376.7	15	0	1	1	2
SIG	24	454.5	25	1	60	8	10 <sup>1</sup> - 25 <sup>2</sup>
<b>Total</b>	100	1397.8					
<b>NOTES:</b> <sup>1</sup> Small channels; <sup>2</sup> Large channels Loading capacities expressed as long term annual average values and do not reflect the wide range spatial and temporal variation observed in natural erosion processes. As new data and methods are developed to better describe sediment delivery mechanisms, the loading capacities may be refined and the TMDL revised.							

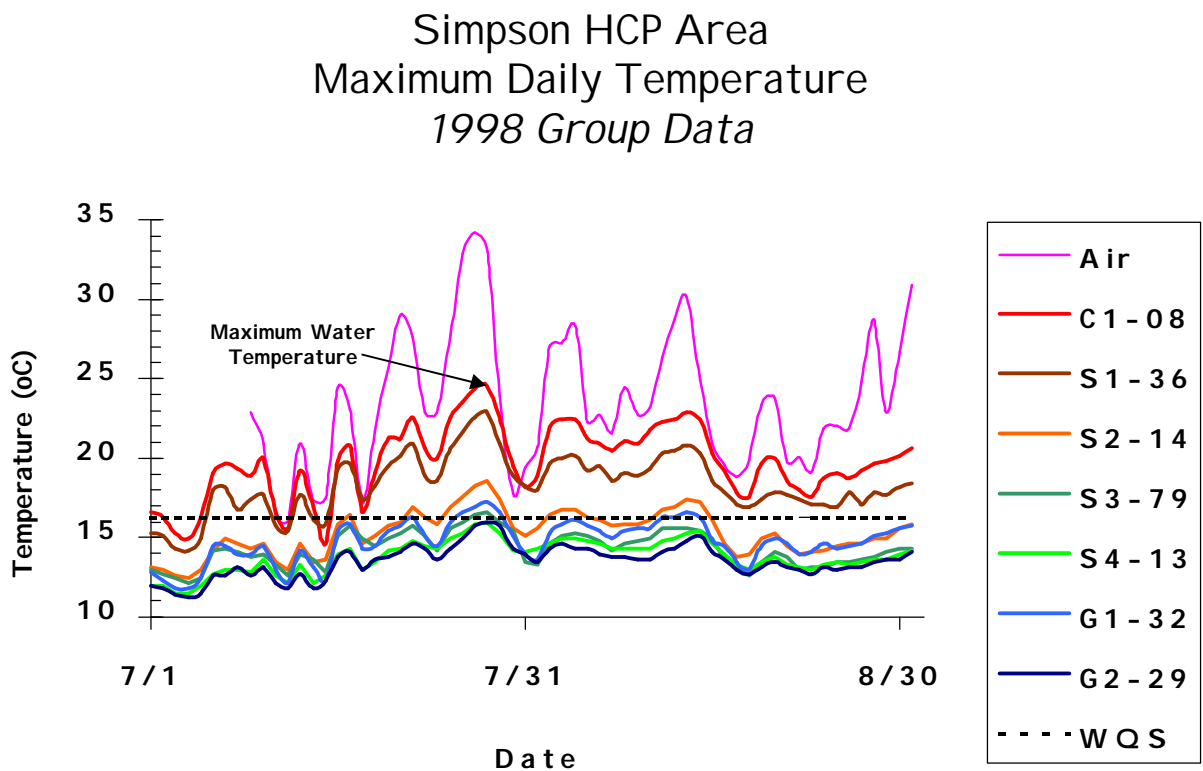
Although an annual averaging period is used to express the loads, it is simply a referencing mechanism. Erosion processes which are responsible for sediment inputs to the system are highly dynamic, change from year-to-year, and vary in different locations in the basin. The main driving factor which affects erosion and sediment inputs from year to year is variability in precipitation, particularly periodic high magnitude storms. The sediment assessment used to develop the loading capacity is based primarily on historical data (e.g. landslide inventories), streamflow patterns, and channel responses to erosion effects. It is difficult to predict future erosion and associated effects because of highly variable weather patterns and changing management practices. It is also infeasible to develop a dynamic, predictive model of future erosion amounts, timing, and locations based on existing information and scientific knowledge.

## 4. DEVIATION FROM TARGETS

### Water Temperature

To put this information in the context of Simpson HCP area streams, limited data has been collected. Figure 4-1 summarizes maximum daily summer water temperature data for streams in the Simpson HCP area. Additional temperature data for the Simpson HCP area is described in the seasonal variation discussion (Section 8).

**Figure 4-1.** Water Temperature for Simpson HCP Area Streams



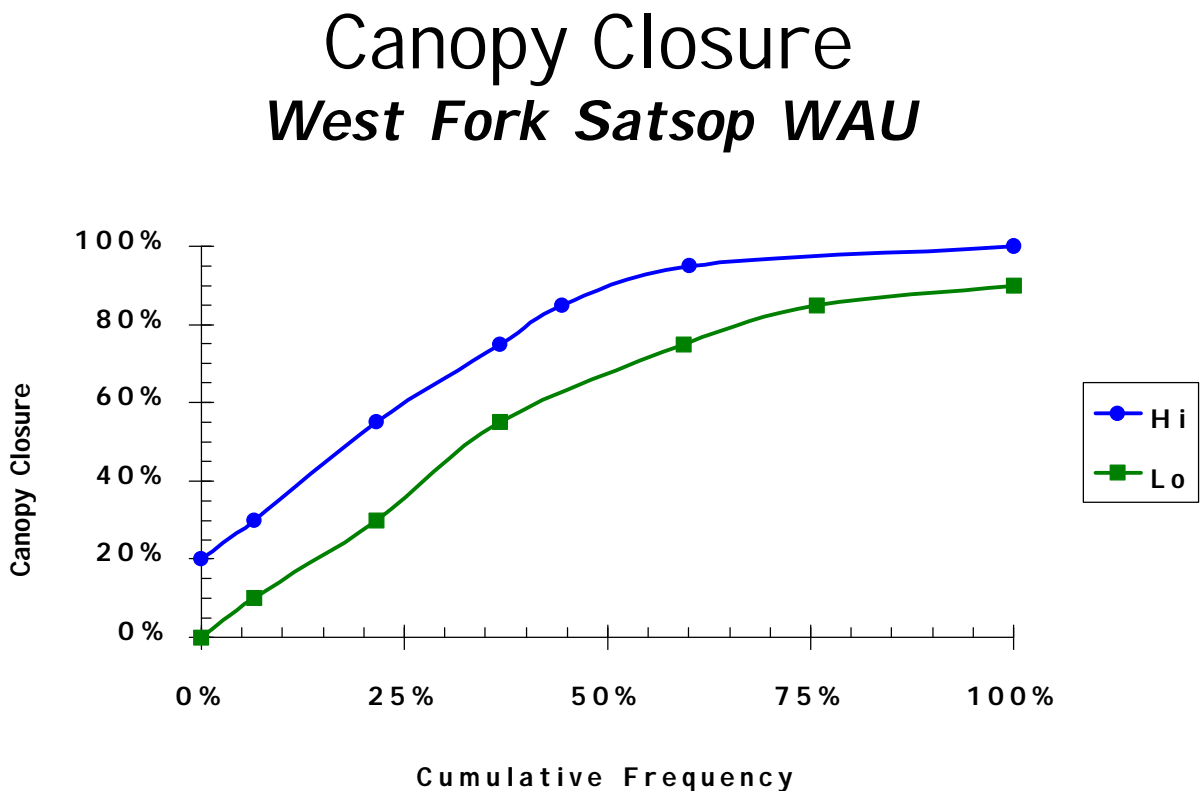
**Simpson Data: 7/1/98 - 8/31/98**

As discussed earlier, water temperatures vary across the landscape which is the reason for developing a “group” approach. In 1998, two of the groups (*S-4 and G2*) did not exceed Washington’s water quality criteria for temperature. This is largely because the strong groundwater influence on these groups makes them more resistant to temperature change. In 1997, a cooler summer, only three of the groups exceeded the water quality criteria. In two cases (*S-1 and S-2*), shade is the dominant control. The third group (*C-1*) is affected by high sediment supply.

### Effective Shade

Targets for effective shade have been developed to address water temperature concerns in the Simpson HCP area. Although no direct measurements of effective shade have been made in the Simpson HCP area, riparian conditions have been evaluated in the Watershed Analysis Reports. The West Fork Satsop Watershed Analysis contains a canopy closure assessment conducted to estimate shade by evaluating existing riparian stands based on air photo information. Canopy closure assessments were done in bracket ranges per the Watershed Analysis Manual (0-20%, 20-40%, 40-70%, 70-90% 90%+). Approximately 160 stream miles were assessed for canopy closure in the Watershed Analysis Unit (WAU). A summary indicates that approximately 60% of the stream miles in the W.F. Satsop watershed are estimated to have adequate canopy closure (*Figure 4-2*).

**Figure 4-2.** W.F. Satsop Canopy Closure Summary

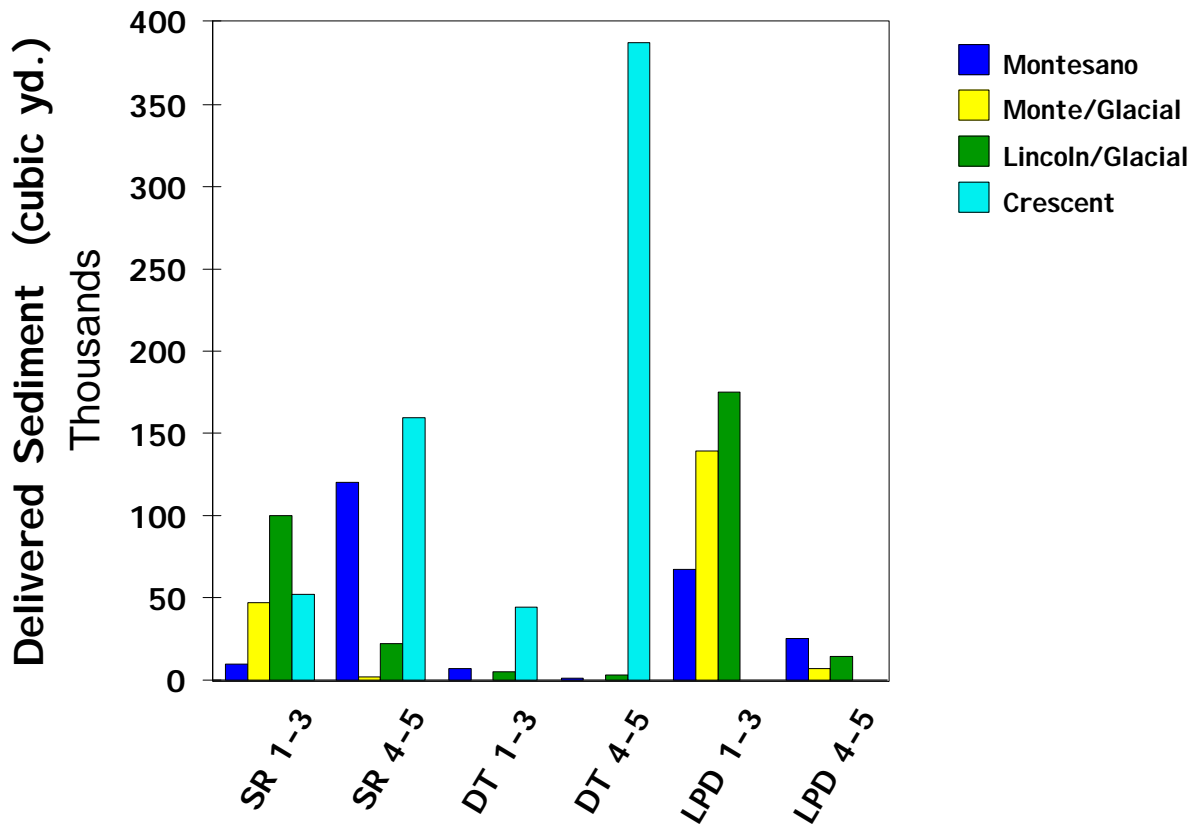


### Sediment Delivery

The W.F. Satsop Watershed Analysis provided estimates of sediment delivery from mass wasting to stream channels in the WAU (*Figure 4-3*). These sediment delivery estimates are apportioned by mass wasting process, receiving water type, and geologic conditions. The W.F. Satsop Watershed Analysis describes the method used to compute sediment delivery volumes from landslide inventory information. The high proportion of large persistent deep-seated (LPD) slides in the Sedimentary Inner Gorge (SIG) results from the prevalence of weak, deeply weathered bedrock, the presence of major incised stream valleys that create riverine escarpments, and the accelerated weathering and valley incision associated with glacial processes.

***Figure 4-3.*** W.F. Satsop Mass Wasting Summary

### ***Grouped by Process and Geology***



## **5. EXISTING SOURCES**

Management activities can increase the amount of solar radiation delivered to a stream system, both by harvesting riparian shade trees and through the introduction of bedload sediment which can lead to channel widening. The Simpson HCP area has experienced a long history of land management, stemming back to the early twentieth century. This has resulted in degradation of the watershed condition. In the Simpson HCP area, anthropogenic sources of thermal gain and other nonpoint source pollution come from land management practices, specifically:

- ! Forest management within riparian areas
- ! Timber harvest in sensitive areas outside the riparian zone
- ! Sediment, hillslope failures, and roads

### **Riparian Area Management and Timber Harvest**

Riparian vegetation can effectively reduce the total daily solar radiation load. Without riparian shade trees, most incoming solar energy would be available to heat the stream. Harvest of riparian area trees from management activities can result in loss of shade. Limited work has been done to estimate the amount of shade loss due to source activities. The W.F. Satsop Watershed Analysis summarized causes for not meeting target shade requirements. The report indicated that approximately 59% of the stream miles assessed met the shade target. Of the remainder, 13% were too wide to be fully shaded and 28% did not meet the shade target because of riparian condition.

### **Sediment, Hillslope Failures, and Roads**

Most of the sediment supply that enters stream channels in forested watersheds is generated by several processes: mass wasting (landsliding), surface erosion (especially from roads), soil creep (especially in unstable areas), and bank erosion (from streamside terraces) [see Paulson, 1997]. This is especially true where steep unstable terrain is subjected to major weather events that saturate hillslopes with large volumes of precipitation. Mass hillslope failures can occur, which deliver large amounts of surface soils to stream channels. These events can overwhelm the capacity of the channel to transport this material downstream, which in turn can lead to substantial channel widening, attendant bank erosion, and shallowing of surface flows. Important salmonid (and associated life forms) habitat features (such as stable spawning areas, pools, side channel rearing areas) can be significantly affected by these processes.

Categories of sediment delivery identified in the Simpson HCP area, several of which are to some extent controllable, include:

- ⇒ background sediment yield
- ⇒ erosion associated with roads, skid trails, and landings
- ⇒ hillslope erosion
- ⇒ mass wasting (landslides)
- ⇒ surface erosion from bare ground (e.g. landslide scars)
- ⇒ bank erosion

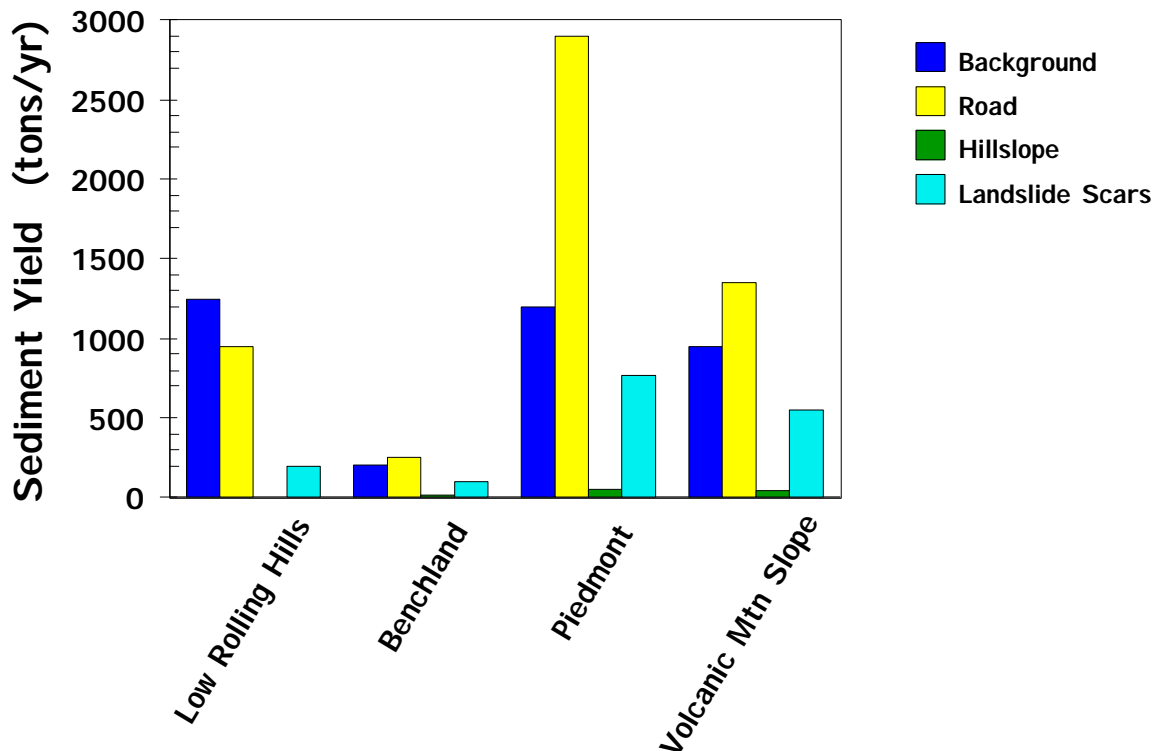
Controllable sediment is sediment delivered as a result of human activities which can affect water quality and can be reasonably controlled. Rates of delivery have been estimated for these sources using several Watershed Analyses conducted within the Simpson HCP area (*Note: Watershed Analysis has not yet been conducted for the entire HCP area*).

### Surface Erosion

Information currently available to develop a detailed sediment budget analysis is fairly limited. However, the W.F. Satsop Watershed Analysis provided an estimate of contributions of fine sediment from various sources in the Watershed Analysis Unit (WAU). This estimate was developed in the Surface Erosion Assessment for comparative purposes to illustrate the approximate quantities of sediment from background and other sources (*Figure 5-1*).

***Figure 5-1.*** W.F. Satsop Surface Erosion Sediment Yield

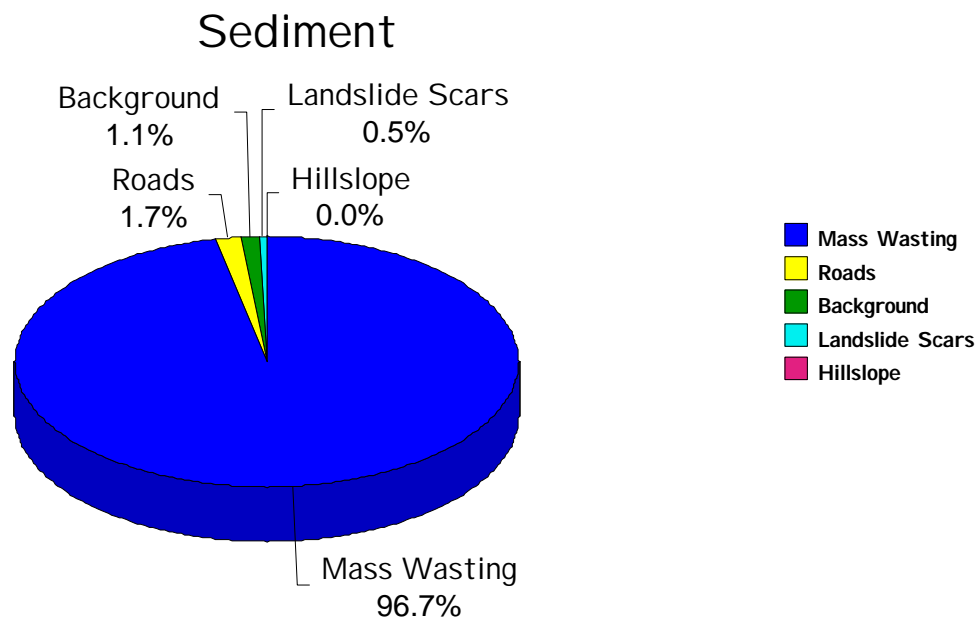
### ***Grouped by Landform and Source Category***



In addition, the W.F. Satsop Watershed Analysis developed an estimate of sediment from all sources to illustrate relative contributions (*Figure 5-2*). This estimate showed that the contribution from mass wasting is far greater than that from surface erosion. It should be noted, though, that the mass wasting value includes both fine and coarse sediment while the background and surface erosion values represent only fine sediment.

***Figure 5-2.*** West Fork Satsop Sediment Yield

### ***Source Summary***



## **6. TMDL / ALLOCATIONS**

This TMDL is designed to address impairments due to surface water temperature increases on four water quality-limited segments located in the Simpson HCP area. In addition to the listed §303(d) waters, this TMDL also applies to other potential water quality impairments from heat and sediment for all streams in the Plan area. In developing the allocations, this TMDL has benefitted from portions of the analysis used in preparation of Simpson's HCP. Although not identical, the goals and legal standards under the ESA and the Clean Water Act for aquatic resources are similar in many respects. Riparian management strategies in the HCP have been designed to eliminate temperature increases due to human activities and to prevent the delivery of excess sediment to the streams. Allocations in the TMDL are designed to achieve similar results.

### **Regulatory Framework**

Under the current regulatory framework for development of TMDLs, flexibility is allowed for specifying allocations in that *"TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure"*. The *"Simpson HCP area TMDL"* utilizes measures other than *"daily loads"* to fulfill requirements of §303(d). Although a loading capacity for heat can be derived [e.g. BTU/ft<sup>2</sup> per day], it is of limited value in guiding management activities needed to solve identified water quality problems. In addition to heat loads, the *"Simpson HCP area TMDL"* uses *"other appropriate measures"* (or surrogates) as provided under EPA regulations [40 CFR §130.2(i)].

### **Allocations**

Allocations in the *"Simpson HCP area TMDL"* are derived using effective shade and sediment delivery targets. These measures can be linked to specific source areas, and thus to actions (specifically riparian management and erosion control) needed to solve problems which cause water temperature increases. Because factors that affect water temperature are interrelated, both measures are dependent upon each other to achieve desirable responses. Using riparian vegetation exclusively to reduce heat (e.g. increase shade) is difficult to achieve if sediment delivered from upland sources continues to deposit and widen channels. Likewise, narrower channels still require riparian vegetation to provide channel stability and shade, thus reducing heat loads (unless confined by canyon walls or shaded by topography).

In establishing the load allocations for this TMDL, certain information has been used that was developed in preparation of the HCP. Sediment delivery information from three completed Watershed Analysis Reports in the Plan area has also been useful. The TMDL develops load allocations for each channel class in the Plan area, then summarizes them into eight separate groups. Streams within each group share common characteristics that relate to potential input of pollutants into streams covered by the TMDL.

The HCP also divides the stream segments into the same eight groups which are identified as individual riparian management strategies (*Table 6-1*). These strategies have been developed using an approach that integrates the mediation of physical processes and ecological functions. For ease of reference, each of the eight groups of streams analyzed separately in this TMDL is given the same name as is used in identifying the corresponding riparian management strategy in the HCP.

***Table 6-1. HCP Riparian Management Strategy Summary***

<b>Strategy</b>	<b>Purpose</b>	<b>Management Function</b>
<b><i>Canyon</i></b>	Maintain sediment and organic matter storage capacity of the upper channel network, keep convective heat transfer to a minimum, and supply detritus to the channel as it's principle energy source.	Provision of LWD from off-site, and maintenance of on site shade and detrital inputs. Applied in the CUP along highly confined channel network of the Olympic foothills.
<b><i>Channel Migration</i></b>	Maintain the floodplain processes that contribute nutrient processing within the soil and hyporheic zone and ensure continued development of topographic complexity of floodplain surfaces.	Retention of sediment and organic matter and maintenance of nutrient processing. Applied to either very large meandering alluvial channels inset within well defined terrace systems or those low gradient smaller channels with highly erodible banks.
<b><i>Temperature Sensitive</i></b>	Mediation of water temperatures in channels that are vulnerable to summer time increases.	Protection of shade and control of streamside air temperature. RCRs established that provide the greatest shade from mid-day to early afternoon ensuring wide, denser leave area on south and west aspects.
<b><i>Inner Gorge</i></b>	Provide wood large enough to maintain position or lodge in channel classes like SI G-L4, SI G-L5, AGL-Qo8, and AGL-Qa6.	Provision of wood from unstable slopes to enhance development of productive main river habitat. Retain largest trees that have the highest likelihood of recruiting to the river.
<b><i>Alluvial Bedrock Transition</i></b>	Maintenance of an alluvial channel bed in channel classes likely to scour to bedrock in the absence of LWD.	Provision of LWD, particularly along channel classes SI G-M3 and SI G-M4. Protect principal recruitment zone for high value LWD.
<b><i>Break in Slope</i></b>	Protect inner side slopes adjacent to channel and provide for LWD recruitment from above the break in slope.	Provision of LWD by establishing RCR back away from the break in slope with emphasis given to wind and shade protection of south and west aspects.
<b><i>Reverse Break in Slope</i></b>	Maintain opportunity for conifer germination sites in an otherwise unfavorable environment by protecting LWD and providing nurse logs.	Provision of LWD and nurse logs. Settings typified by wet understory plant communities whose early seral stages are dominated by red alder.
<b><i>Unstable Slopes / Intermittent Flow</i></b>	Maintain important functional linkages between channel segments and their riparian areas for channel classes that typically have low average fish resource value.	Recognition of physical processes that may transmit significant impacts from these channel classes to other segments downstream for which on-site biological resource value is high.

***Effective Shade Allocations:*** The objective of the effective shade TMDL is to reduce heat from incoming solar radiation delivered to the water surface. The basis for effective shade allocations follows an analysis of processes that affect water temperature. Development of the effective shade allocations uses information about riparian management strategies described in the HCP. Minimum Riparian Conservation Reserve (RCR) widths described in the HCP recognize the relationship between active channel width and effective shade.

Effective shade allocations have been developed from targets based on channel class width and characteristics of mature riparian vegetation (*Table 6-2*) for that channel class including vegetative density. Effective shade allocations are a function of the vegetation that will shade the widest active channel for each class. The active channel width, the vegetative density associated with a particular RCR width, and the height associated with the expected riparian community (e.g. mixed conifer / hardwood) is used to determine effective shade allocations.

**Table 6-2.** Mature Riparian Vegetation Classes in HCP Area

<b>ID</b>	<b>Stage</b>	<b>Vegetation Description</b>
<b>H-M</b>	<b>Mature</b>	<b>Hardwood:</b> Salmonberry, Thimbleberry (< 6 ft) Devil's Club (< 15 ft) Vine Maple (< 50 ft) Red Alder, Big Leaf Maple
<b>M-M</b>	<b>Mature</b>	<b>Mixed:</b> Listed Hardwoods Listed Conifers
<b>C-M</b>	<b>Mature</b>	<b>Conifer:</b> Douglas Fir, Red Cedar Western Hemlock, Sitka Spruce

As channels become wider, larger RCR widths are needed to provide more effective shade, as well as to protect other riparian functions. This is reflected in the HCP where wider channels have larger RCR widths identified. Small channels ( $\leq 4\text{m}$ ), on the other hand, benefit from dense, emergent vegetation. Consequently, narrower RCR widths may still provide a high level of effective shade to these small streams. However, the benefit of the RCR to these smaller channels may go beyond effective shade. As indicated in the HCP, the purpose of the RCR is also to provide slope stability and a supply of large woody debris (LWD).

The “*Simpson HCP area TMDL*” and allocations for effective shade are summarized in Table 6-3. Some items to note relative to the effective shade allocations include variations between active channel width and minimum RCR widths. In many instances, channels of the same width size have different RCR widths. The temperature group and other considerations (e.g. LWD supply, sediment supply concerns) become important factors, particularly in terms of uncertainty and increasing the margin of safety. The 8-meter active channel width is used to illustrate this point. AGL-Qo5 and AGL-Qo6 streams are in temperature group S-4 (i.e. those streams strongly influenced by groundwater and more resistant to temperature change). As a result, this class of streams has a lower margin of safety. In contrast, CUP-C4 and ROP-C7 are in areas where sediment supply is a potential concern. Therefore, larger RCR widths are identified in the HCP for this class of streams.

*Sediment Delivery:* The “*Simpson HCP area TMDL*” and allocations for sediment delivery are summarized in Table 6-4. The estimated total allowable sediment load (TMDL) is derived from targets based on lithotopo unit, channel class and erosion process (cubic yards per mile per averaging period). Sediment delivery information for the period 1946-96 was used from three completed Watershed Analysis reports conducted in the Simpson HCP area.

Analysis of sediment delivery information from landslide inventories indicates two major concerns that contribute to management caused hillslope instability. First, riparian area management can affect sediment delivery through bank stability and sediment retention. For instance, the W.F. Satsop Watershed Analysis identified the main potential management influence in the SIG as declining root reinforcement of hillslopes following harvest. The second concern relates to roads, particularly in the Crescent Uplands. Again, the W.F. Satsop Watershed Analysis indicated that road sidecast and cutslope problems are the source of more than half the inventoried slides in the CUP.

Sediment delivery allocations use information from three completed Watershed Analysis Reports in the area and from several inventories that supported preparation of the HCP. The quantitative comparison of estimated loading rates and controllable portions of various types of loading was considered. It is estimated that a 50% reduction in the frequency of catastrophic failures (e.g. sidecast or fill failures) over the rate observed for the previous 20-year period can be achieved during the first ten years of the Plan. This represents an interim target for measuring progress relative to achieving the load allocations. In addition, a target of 50% reduction of fine sediment input from roads during the first ten years of the plan is also included in the HCP. Furthermore, the HCP provides funding to road maintenance and abandonment efforts for the duration of the HCP. Finally, STC will apply mass wasting prescriptions across the HCP area to address unstable slope concerns.

The load allocations incorporate sediment reductions from management activities into the sediment delivery targets. Sediment delivered from shallow rapids landslides and debris torrents as a result of management activities is assumed to be 80% controllable. This is based on information used for development of prescriptions in the W.F. Satsop Watershed Analysis. Sediment delivered from large persistent deep-seated landslides as a result of management activities is assumed to be 50% controllable. The retention of large wood in RCRs and reducing peak flows due to hydrologic effects of the road network will address sediment delivery from bank erosion that result from management activities.

Sediment delivery targets expressed as annual average cubic yards per stream mile for each channel class is consistent with current EPA regulations. The regulations indicate that load allocations are *“best estimates of the loading which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading”* [40 CFR §130.2(g)].

The resultant load allocations for sediment are: 1) developed for erosion processes; 2) associated with land use activities where feasible; and 3) based on the source analysis of various erosion processes. The load allocations are expressed as long term annual average load delivered per mile at the channel class scale. Temporal and spatial variability in erosion and stream responses are considered in several ways including:

- ☞ *Temporal Considerations* -- The TMDL and specific load allocations are expressed in terms of annual rates over a 50-year period in recognition that trends are not discernible within shorter time frames and to allow for natural variation due to seasonal and annual differences.
- ☞ *Spatial Considerations* -- Targets were derived based primarily on analysis of conditions in different watersheds and lithotopo units within the Simpson HCP area. These conditions represent different geologies and associated vulnerabilities to erosion.

**Table 6-3a.** Summary of Effective Shade TMDL and Load Allocations for Simpson HCP Area

Channel Class	Group	Active Channel Width (m)	Avg. RCR Width (m)	Riparian Condition	Length (miles)	Load Allocations (Effective Shade as percent)		
						TMDL	LA	MOS
Temperature Sensitive Strategy								
ROP-Qc3	S-1	6 - 12	30/25	C-M	44.2	89%	90%	(1%)
SIG-Qc3	S-1	4 - 10	25/15	C-M	9.1	87%	90%	(3%)
Total for Strategy					53.3	88.7%	90.0%	(1.3%)
Break in Slope Strategy								
AGL-Qo3	S-4	2 - 4	25/15	M-M	7.3	76%	96%	(20%)
AGL-Qo5	S-4	4 - 8	20/10	C-M	8.8	76%	93%	(17%)
AGL-Qo6	S-4	6 - 8	30/20	C-M	13.6	76%	92%	(16%)
AGL-Qo7	S-4	12 - 16	30/20	C-M	3.7	80%	82%	(2%)
ROP-Qc2	S-1	2 - 4	3	M-M	103.4	90%	92%	(2%)
ROP-Qc4	G-1	4 - 6	20/15	C-M	9.1	85%	96%	(11%)
ROP-Qc5	G-1	12 - 18	30/20	C-M	12.1	75%	81%	(6%)
SIG-L3	S-2	2 - 4	20/15	M-M	6.3	84%	97%	(13%)
SIG-Qo3	S-4	4	25/15	M-M	4.8	78%	96%	(18%)
SIG-Qo4	S-4	8 - 16	30	C-M	2.0	82%	84%	(2%)
Total for Strategy					171.1	85.4%	91.6%	(6.3%)
TMDL								
Notes: <sup>1</sup> TMDL currently refers to temperature group described in Section 3. Development of allocations based on representative conditions for mature riparian condition, maximum active channel width for class, and minimum Riparian Conservation Reserve (RCR) width.								

**Table 6-3b.** Summary of Effective Shade TMDL and Load Allocations for Simpson HCP Area

Channel Class	Group	Active Channel Width (m)	Avg. RCR Width (m)	Riparian Condition	Length (miles)	Load Allocations (Effective Shade as percent)		
						TMDL	LA	MOS
Canyon Strategy								
CUP-C2	G-2	2 - 4	25	M-M	22.9	68%	95%	(27%)
CUP-C3	G-2	2 - 4	25	M-M	24.5	68%	95%	(27%)
CUP-C4	G-2	6 - 8	25	C-M	4.9	68%	91%	(23%)
CUP-C5	G-2	4 - 6	25	C-M	3.5	68%	95%	(27%)
CUP-C6	G-2	12	30	C-M	3.6	68%	86%	(18%)
Total for Strategy					59.4	68.0%	94.1%	(26.1%)
Channel Migration Strategy								
AGL-Qa6	C-1	> 25	40/30	C-M	12.7	77%	77%	(0%)
CIS-Qc3	S-3	8 - 16	30/20	C-M	16.8	83%	85%	(2%)
ROP-C7	C-1	6 - 8	40	C-M	9.4	89%	94%	(5%)
ROP-Qa7	C-1	> 16	50/40	C-M	3.7	85%	85%	(0%)
ROP-Qc6	G-1	12	40/30	C-M	9.5	75%	89%	(14%)
ROP-Qc7	G-1	15	65/40	C-M	15.2	75%	86%	(11%)
ROP-Qc8	C-1	25	40	C-M	2.8	82%	82%	(0%)
SIG-M6	S-2	6 - 12	50/30	C-M	2.3	85%	89%	(4%)
SIG-Qa6	C-1	> 25	40	C-M	11.3	77%	77%	(0%)
Total for Strategy					83.7	79.7%	84.4%	(4.7%)
TMDL								
Notes: <sup>1</sup> TMDL currently refers to temperature group described in Section 3. Development of allocations based on representative conditions for mature riparian condition, maximum active channel width for class, and minimum Riparian Conservation Reserve (RCR) width.								

## APPENDIX G: TMDL TECHNICAL ASSESSMENT REPORT

**Table 6-3c.** Summary of Effective Shade TMDL and Load Allocations for Simpson HCP Area

Channel Class	Group	Active Channel Width (m)	Avg. RCR Width (m)	Riparian Condition	Length (miles)	Load Allocations (Effective Shade as percent)		
						TMDL	LA	MOS
Inner Gorge Strategy								
AGL-Qo8	G-2	15 - 25	30	C-M	5.2	58%	74%	(16%)
CUP-C8	G-2	20	35	C-M	5.9	72%	81%	(9%)
SIG-L4	C-1	35	40	C-M	24.2	72%	72%	(0%)
SIG-M5	C-1	20	40	C-M	15.1	72%	86%	(14%)
Total for Strategy					50.4	70.6%	77.5%	(6.9%)
Alluvial Bedrock Transition Strategy								
SIG-M3	S-2	4 - 12	30/15	C-M	9.6	85%	88%	(3%)
SIG-M4	S-2	4 - 12	40/25	C-M	6.0	85%	89%	(4%)
Total for Strategy					15.6	85.0%	88.4%	(3.4%)
Reverse Break in Slope Strategy								
AGL-Qo4	S-2	4 - 6	30/20	C-M	2.6	82%	95%	(13%)
CIS-C5	G-1	4 - 6	40/30	C-M	1.7	85%	95%	(10%)
SIG-L2	S-2	2 - 4	30/20	M-M	38.5	84%	95%	(11%)
Total for Strategy					42.8	83.9%	95.0%	(11.1%)
TMDL								
Notes: <sup>1</sup> TMDL currently refers to temperature group described in Section 3. Development of allocations based on representative conditions for mature riparian condition, maximum active channel width for class, and minimum Riparian Conservation Reserve (RCR) width.								

**Table 6-3d.** Summary of Effective Shade TMDL and Load Allocations for Simpson HCP Area

Channel Class	Group	Active Channel Width (m)	Avg. RCR Width (m)	Riparian Condition	Length (miles)	Load Allocations (Effective Shade as percent)		
						TMDL	LA	MOS
Unstable Slopes / Intermittent Flow Strategy								
AGL-Qo1	G-2	0 - 4	8	M-M	61.3	51%	93%	(42%)
AGL-Qo2	S-2	< 2	8	M-M	22.5	82%	93%	(11%)
CIS-C1	G-2	0 - 4	8	M-M	83.9	71%	93%	(22%)
CIS-Qc1	S-3	0 - 4	8	M-M	33.3	85%	93%	(8%)
CIS-Qc2	S-3	2 - 4	8	M-M	28.0	85%	93%	(8%)
CUP-C1	G-2	0 - 2	8	M-M	199.9	68%	93%	(25%)
ROP-Qc1	S-1	2 - 4	8	M-M	167.3	90%	93%	(3%)
SIG-L1	S-2	0 - 2	8	M-M	160.0	84%	93%	(9%)
SIG-M1	S-2	1 - 2	8	M-M	67.8	84%	93%	(9%)
SIG-M2	S-2	2 - 4	8	M-M	18.5	84%	93%	(9%)
SIG-Qc1	S-3	2 - 4	8	M-M	12.8	80%	93%	(13%)
SIG-Qc2	S-3	2 - 4	8	M-M	8.9	80%	93%	(13%)
SIG-Qo1	G-2	0 - 4	8	M-M	38.3	56%	93%	(37%)
SIG-Qo2	S-2	2 - 4	8	M-M	19.0	84%	93%	(9%)
Total for Strategy					921.5	77.0%	93.0%	(16.0%)
TMDL								
Notes: 1 TMDL currently refers to temperature group described in Section 3. Development of allocations based on representative conditions for mature riparian condition, maximum active channel width for class, and minimum Riparian Conservation Reserve (RCR) width.								

**APPENDIX G: TMDL TECHNICAL ASSESSMENT REPORT**

**Table 6-4a.** Sediment Allocations by Channel Class for Simpson HCP Area

Channel Class	Length (miles)	TMDL	Mass Wasting			Surface Erosion	Bank Erosion	MOS
			SR	DT	LPD			
Temperature Sensitive Strategy								
ROP-Qc3	44.2	19	12	0	1	1***	2***	3
SIG-Qc3	9.1	112	20	1	35	8	17***	15
Total	53.3	32.1	13.4	0.2	6.8	2.2	4.6	4.9
Break in Slope Strategy								
AGL-Qo3	7.3	53	12*	1	15	4***	8***	13
AGL-Qo5	8.8	53	12*	1	15	4	8	13
AGL-Qo6	13.6	53	12	1	15	4***	8***	13
AGL-Qo7	3.7	53	12*	1	15	4***	8	13
ROP-Qc2	103.4	19	12*	0	1	1	2	3
ROP-Qc4	9.1	19	12*	0	1	1	2	3
ROP-Qc5	12.1	19	12	0	1	1	2***	3
SIG-L3	6.3	112	20*	1	50	8	17	15
SIG-Qo3	4.8	112	20*	1	50	8	17	15
SIG-Qo4	2.0	112	20*	1	50*	8	17	15
Total	171.1	32.8	12.6	0.3	7.5	2.1	4.3	6.0
Canyon Strategy								
CUP-C2	22.9	80	15*	15*	1	3	6	40
CUP-C3	24.5	80	15*	15*	1	3	6	40
CUP-C4	4.9	80	15*	15*	1	3	6	40
CUP-C5	3.5	80	15*	15*	1	3	6	40
CUP-C6	3.6	80	15*	15*	1	3	6	40
Total	59.4	80.0	15.0	15	1.0	3.0	6.0	40.0

**APPENDIX G: TMDL TECHNICAL ASSESSMENT REPORT**

**Table 6-4b.** Sediment Allocations by Channel Class for Simpson HCP Area

Channel Class	Length (miles)	TMDL	Mass Wasting			Surface Erosion	Bank Erosion	MOS
			SR	DT	LPD			
Channel Migration Strategy								
AGL-Qa6	12.7	53	12*	1	15	4	8***	13
CIS-Qc3	16.8	23	12*	0	1	2***	4	3
ROP-C7	9.4	19	12	0	1	1	2	3
ROP-Qa7	3.7	19	12*	0	1	1	2***	3
ROP-Qc6	9.5	19	12	0	1	1	2***	3
ROP-Qc7	15.2	19	12	0	1	1***	2	3
ROP-Qc8	2.8	19	12	0	1	1	2***	3
SIG-M6	2.3	112	20	1	50	8	17***	15
SIG-Qa6	11.3	124	20*	1	50	12	25***	15
Total	83.7	41.5	13.3	0.3	11.1	3.3	6.8	6.7
Inner Gorge Strategy								
AGL-Qo8	5.2	53	12	1	15	4	8	13
CUP-C8	5.9	80	15	15	1	3	6	40
SIG-L4	24.2	124	20*	1	50*	12	25	15
SIG-M5	15.1	124	20*	1	50	12	25	15
Total	50.4	111.5	18.6	2.6	40.7	10.1	21.0	18.5
Alluvial Bedrock Transition Strategy								
SIG-M3	9.6	112	20*	1	35	8	17	15
SIG-M4	6.0	112	20*	1	35	8	17	15
Total	15.6	96.0	20.0	1.0	35.0	8.0	17.0	15.0

**Table 6-4c.** Sediment Allocations by Channel Class for Simpson HCP Area

Channel Class	Length (miles)	TMDL	Mass Wasting			Surface Erosion	Bank Erosion	MOS
			SR	DT	LPD			
Reverse Break in Slope Strategy								
AGL-Qo4	2.6	53	12	1	15	4***	8***	13
CIS-C5	1.7	23	12	0	1	2***	4***	3
SIG-L2	38.5	72	20*	1	20	5	10	15
Total	42.8	59.9	19.2	1.0	18.9	4.8	9.6	6.4
Unstable Slopes / Intermittent Flow Strategy								
AGL-Qo1	61.3	53	12*	1	15	4***	8	13
AGL-Qo2	22.5	53	12	1	15	4***	8	13
CIS-C1	83.9	23	12*	0	1	2***	4	3
CIS-Qc1	33.3	23	12*	0	1	2***	4***	3
CIS-Qc2	28.0	23	12	0	1	2***	4***	3
CUP-C1	199.9	80	15*	15*	1	3	6	40
ROP-Qc1	167.3	19	12	0	1	1***	2	3
SIG-L1	160.0	72	20*	2	20	5	10***	15
SIG-M1	67.8	72	20*	2	20	5	10***	15
SIG-M2	18.5	72	20*	2	20	5***	10	15
SIG-Qc1	12.8	72	20*	2	20	5	10***	15
SIG-Qc2	8.9	72	20	2	20	5	10***	15
SIG-Qo1	38.3	72	20*	2	20	5***	10	15
SIG-Qo2	19.0	72	20	2	20	5***	10	15
Total	921.5	51.0	15.5	3.7	9.0	3.3	6.6	12.9

## **7. MARGIN OF SAFETY**

The Clean Water Act requires that each TMDL be established with a margin of safety (MOS). The statutory requirement that TMDLs incorporate a margin of safety is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A margin of safety is expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions).

The margin of safety may be implicit, as in conservative assumptions used in calculating the loading capacity, WLAs, and LAs. The margin of safety may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the margin of safety documented. The margin of safety is not meant to compensate for a failure to consider known sources. Table 7-1 presents six approaches for incorporating a margin of safety into TMDLs.

**Table 7-1.** Approaches for Incorporating a Margin of Safety into a TMDL

<b>Type of Margin of Safety</b>	<b>Approaches</b>
<b>Explicit</b>	<ol style="list-style-type: none"> <li>1. Set numeric targets at more conservative levels than analytical results indicate</li> <li>2. Add a safety factor to pollutant loading estimates</li> <li>3. Do not allocate a portion of available loading capacity; reserve for MOS</li> </ol>
<b>Implicit</b>	<ol style="list-style-type: none"> <li>4. Conservative assumptions in derivation of numeric targets</li> <li>5. Conservative assumptions when developing numeric model applications</li> <li>6. Conservative assumptions when analyzing prospective feasibility of practices and restoration activities.</li> </ol>

The following factors may be considered in evaluating and deriving an appropriate margin of safety:

- ☞ Limitations in available data to characterize the waterbody / pollutant and to address the components of the TMDL development process.
- ☞ Analysis and techniques used in to evaluate components of the TMDL and to derive an allocation scheme.
  - ✓ characterization and estimates of source loadings (e.g., confidence regarding data limitation, analysis limitation or assumptions)
  - ✓ analysis of relationships between the source loading and instream impact
  - ✓ prediction of response of receiving waters under various allocation scenarios. (e.g., the predictive capability of the analysis, simplifications in the selected techniques)

- ☞ Expression of analysis results in terms of confidence intervals or ranges. Confidence may be addressed as a cumulative effect on the load allocation or for each of the individual components of the analysis.
- ☞ Implications of the MOS on the overall load reductions identified in terms of reduction feasibility and implementation time frames.

### Assumptions

Effective Shade: Development of effective shade allocations results from an analysis of processes that affect water temperature and from information about Riparian Management Strategies described in the HCP. The analysis of processes that affect water temperature include use of a heat budget. There are a number of uncertainties in the analysis regarding these processes that both add and subtract heat from a stream system. Assumptions that affect analytical results include factors such as flow, channel width, upstream water temperature, wind speed, relative humidity, stream bed composition, and groundwater contribution. Figure 7-1 illustrates an example of the range of uncertainty associated with different assumptions in developing effective shade targets.

**Figure 7-1.** Example of Range of Uncertainty in Developing Effective Shade Targets

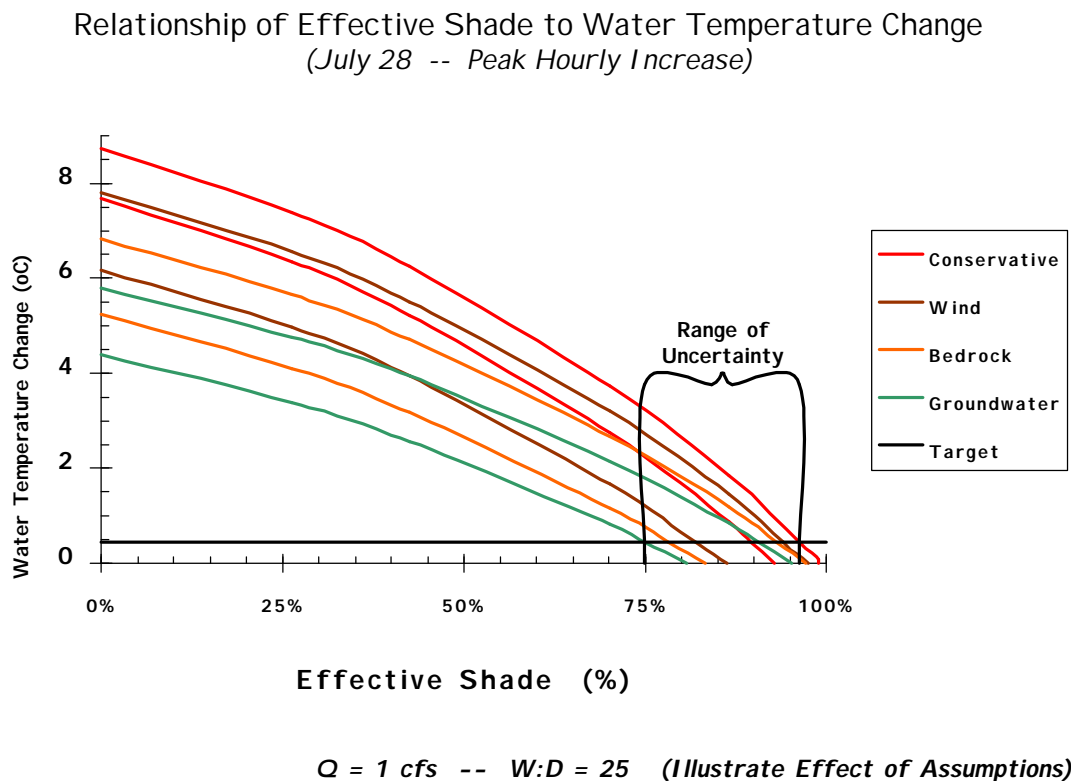


Table 7-2 summarizes uncertainties associated with development of effective shade targets. Adjustments that were made to account for these uncertainties are also described.

**Table 7-2.** Supporting Information for Effective Shade Margin of Safety

Uncertainties in TMDL	Adjustments to Account for Uncertainties
Natural conditions of upstream ambient water temperature regimes for some segments may be above state criteria of 16 C.	Focus analysis on identifying heat input and effective shade targets to achieve a peak hourly temperature increase of 0.45 C which serves as a numeric interpretation of the “ <i>natural conditions</i> ” clause in Washington’s water quality standards. As new data and methods are developed to better describe “ <i>Natural conditions</i> ”, the peak hourly temperature increase target may be refined.
Maximum water temperatures can occur over a range of days which vary from mid-July to mid-August.	Effective shade allocations are based on shadows cast on June 21 when shade angle and solar radiation values are at their peak.
Very little information exists regarding factors that affect water temperature in the Simpson HCP area, particularly wind speed, relative humidity, stream bed composition, and groundwater contribution.	Once the HCP agreement is in place, monitoring of water temperature will continue with a focus on temperature group patterns. Information from this network will support modifications to assumptions, as warranted.

Allocations for effective shade contain an explicit margin of safety which is expressed as an unallocated portion of the loading capacity. In many cases, this portion is unallocated because of other factors in the Riparian Management Strategy which applies to that particular channel class. Considerations include providing for slope stability or future recruitment of large wood (e.g. Break in Slope, Canyon strategies).

In addition, allocations for effective shade also contain an implicit margin of safety, specifically the point of measurement for the Riparian Conservation Reserve (RCR). These buffer widths, identified in the HCP and in the load allocations, were determined by identifying the primary zones adjacent to each channel class where the functional interactions with the riparian forest are most pronounced. The HCP buffer widths reflected in the load allocations differ from other traditional approaches that use the ordinary high water (OHW) mark as the measurement benchmark. In the HCP, both the channel migration zone and side slope surfaces are accorded full, no harvest protection by the “*Break in Slope*” riparian strategy. The width of these width of these zones are actually measured from the break in slope instead of the OHW and do not count the side slope distance from the start of the RCR to the edge of the channel migration zone.

***Sediment Delivery:*** Development of sediment budget values is an “*order of magnitude*” estimate which may result in over prediction or under prediction of loadings from different erosion processes. Uncertainties about mass wasting and streambank erosion portions of the analysis can be significant. The uncertainties include:

- A single volume assigned to an individual landslide for the entire budget period could inaccurately represent volumes of sediment production during the budget period, depending on when the landslide first appeared and whether it enlarged during the budget period.
- Assumptions about the volumes of sediment delivery from landslide types or slope positions may be incorrect.
- Errors can be made in identifying landslides and in estimating sizes from aerial photographs.
- The two sources of landslide inventories differed slightly in assumptions, e.g. soil depth.
- It is difficult to accurately identify management activities associated with individual landslides generated by cumulative effects of land management activities above the landslides (e.g. failures within an inner gorge).
- Bank erosion causes cannot be accurately assigned to management or non-management activities.
- Surface erosion estimates cannot account for roads that are not included in the coverage, nor can it account for skid trails and landings unless they generated mass wasting failures.

Table 7-3 summarizes uncertainties from the sediment delivery source analysis. Adjustments that were made to account for these uncertainties are described.

***Table 7-3.*** Supporting Information for Sediment Delivery Margin of Safety

Uncertainties in TMDL	Adjustments to Account for Uncertainties
Instream indicators of sediment not used because of lack of site specific information for these parameters. Extrapolation of values derived from dissimilar areas may have limited relevance in development of instream targets for Simpson HCP area.	Once an HCP agreement is in place, the expectation is that such habitat information will be collected from the extensive monitoring program commitments made by Simpson. This issue can be revisited at year 10 of the plan implementation, and adjustments made, as deemed appropriate by the participants. Note that this alternative approach makes good use of the fundamental landscape and channel classification system Simpson has developed for the HCP.
The role of sediment storage in channel systems as both a source and sink for sediment is poorly understood.	The TMDL gives no “ <i>credit</i> ” for instream storage as a consideration in TMDL determination because current excessive levels of instream stored sediment are contributing to temperature increases in C-1 group. The TMDL is lower than would be the case if instream storage credit were provided.

### **Adaptive Management**

Establishing TMDLs employs a variety of analytical techniques. Some analytical techniques are widely used and applied in evaluation of source loading and determination of the impacts on waterbodies. For certain pollutants, such as heat and sediment, the methods used are newer or in development. The selection of analysis techniques is based on scientific rationale coupled with interpretation of observed data. Concerns regarding the appropriateness and scientific integrity of the analysis have been defined and the approach for verifying the analysis through monitoring and implementation addressed. Without the benefit of long term experience and testing of the methods used to derive TMDLs, the potential for the estimate to require refinement is high.

A TMDL and margin of safety which is reasonable and results in an overall allocation represents the best estimate of how standards can be achieved. The selection of the MOS can also clarify the implications for monitoring and implementation planning in refining the estimate if necessary (adaptive management). *"Adaptive management"* is often defined as the reliance on scientific methods to test the results of actions taken so that the management and related policy can be changed promptly and appropriately. The FACA report indicated that *"adaptive management involves setting goals and developing implementation plans based on existing data, providing for additional data gathering and monitoring of results achieved, and revising goals and implementation plans as appropriate in light of the subsequent data and monitoring"*.

The TMDL process accommodates the ability to track and ultimately refine assumptions within the TMDL implementation planning component. The *"Simpson HCP area TMDL"* is intended to be adaptive in management implementation. This plan allows for future changes in loading capacities and surrogate measures (allocations) in the event that scientifically valid reasons support alterations. It is important to recognize the continual study and progression of understanding of water quality parameters addressed in this TMDL (e.g. stream temperature, sediment, riparian condition, habitat). The Simpson HCP addresses future monitoring plans. In the event that data show that changes are warranted in the Simpson TMDL, these changes will be made.

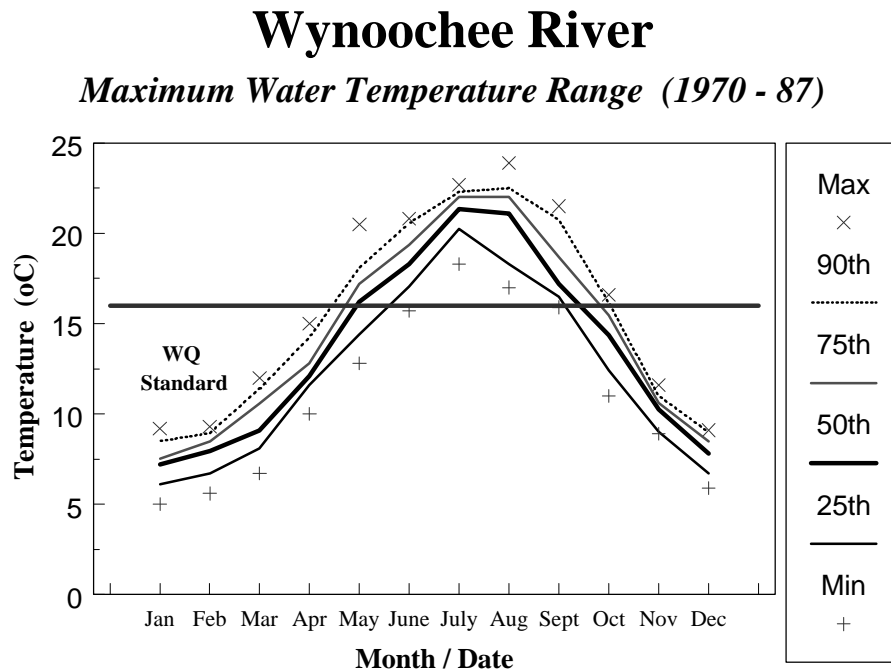
## 8. SEASONAL VARIATION

Section 303(d)(1) requires that TMDLs “be established at level necessary to implement the applicable water quality standards with seasonal variations”. The current regulation also states that determination of “TMDLs shall take into account critical conditions for stream flow, loading, and water quality parameters” [40 CFR 130.7(c)(1)]. In addition, §303(d)(1)(D) suggests consideration of normal conditions, flows, and dissipative capacity. This information is summarized in the following discussion.

### Existing Conditions

Existing conditions for stream temperatures in the Simpson HCP area reflect seasonal variation. Cooler temperatures occur in the winter, while warmer temperatures are observed in the summer. Historical data has been collected by the U.S. Geological Survey (USGS) of stream temperatures in the Wynoochee River. Figure 8-1 summarizes the distribution of highest daily maximum water temperatures for each month between 1970 and 1987. Although the data was collected in the 1970's and 80's, it is the most comprehensive record for water temperature taken at one site over an extended period of time in the vicinity of the Simpson HCP area. As shown, water quality standards for temperature are only exceeded between May and October. In addition, the data shown in Figure 8-1 indicates that the highest seven-day average maximum water temperatures occur between mid-July and mid-August. This time frame is used as the critical period for development and analysis of allocations in the TMDL.

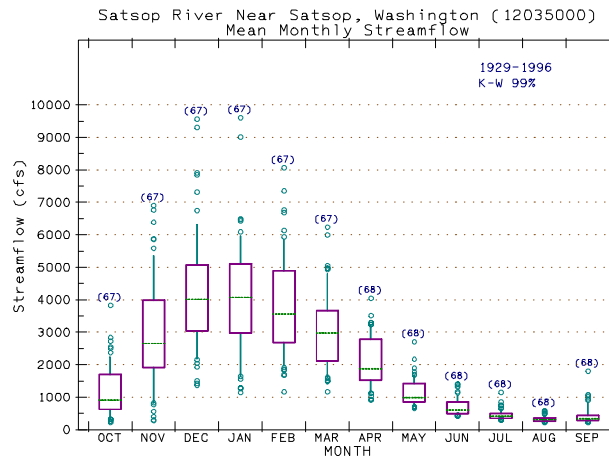
**Figure 8-1.** Seasonal Variation of Wynoochee Temperature Levels



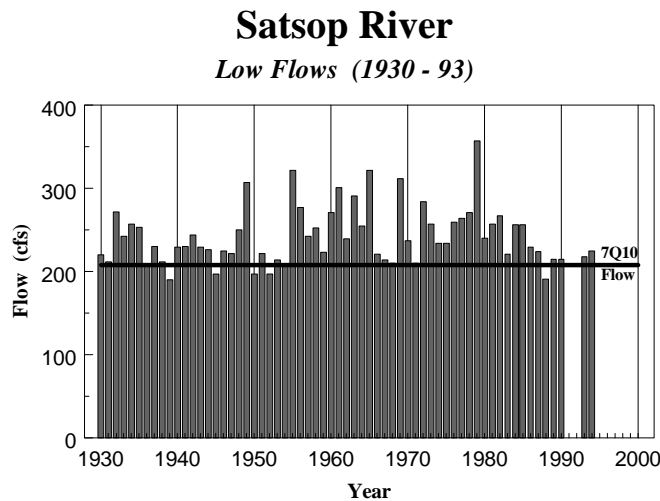
## Stream Flow

Monthly flow data is another way to describe seasonal variation. As illustrated in Figure 8-2, flows peak in December as a result of winter storm runoff. Flows decline through the summer reaching baseflow conditions in August. Figure 8-3 depicts the variability of seven-day low flows using data from the Satsop River near Satsop. The seven-day low flow recurring every ten years (7Q10) is also shown in Figure 8-3. The USGS data has been used to describe the variation of 7Q2 values across the HCP area (Amerman and Orsborn, 1987). From this information, a relationship has been developed to estimate 7Q2 values for various LTU's within the HCP area.

**Figure 8-2.** Flow Patterns for Satsop River



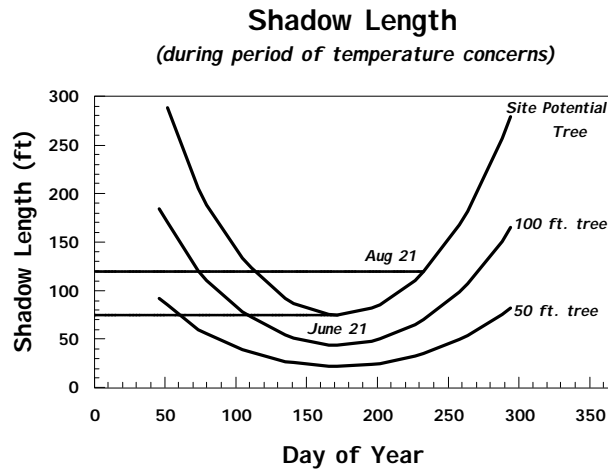
**Figure 8-3.** Satsop River Low Flow History



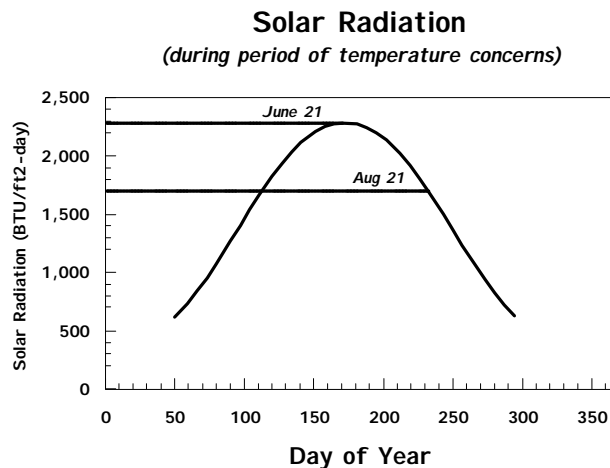
### Solar Radiation

Potential solar radiation varies throughout the year. The highest value occurs on the first day of summer when the earth's tilt towards the sun is greatest. Figure 8-4 illustrates the effect of seasonal variation on shadow length associated with different tree heights. As shown, shadows are shortest in mid-June. Figure 8-5 illustrates the effect of seasonal variation on maximum potential solar radiation. Mid-June is the period when solar radiation values are at their peak. As a result, mid-June can be used a starting point for identifying the loading capacity for effective shade. This is the time that the water surface receives the maximum potential solar radiation and when riparian shade is least effective in reducing heat. This does add to the margin of safety because low flows and maximum water temperatures typically occur between mid-July and mid-August.

**Figure 8-4.** Seasonal Variation of Shadow Lengths



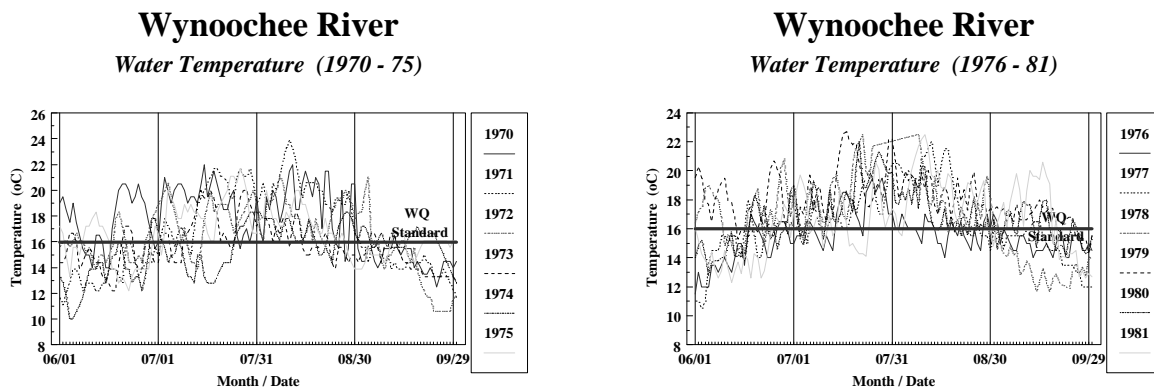
**Figure 8-5.** Seasonal Variation of Maximum Potential Solar Radiation



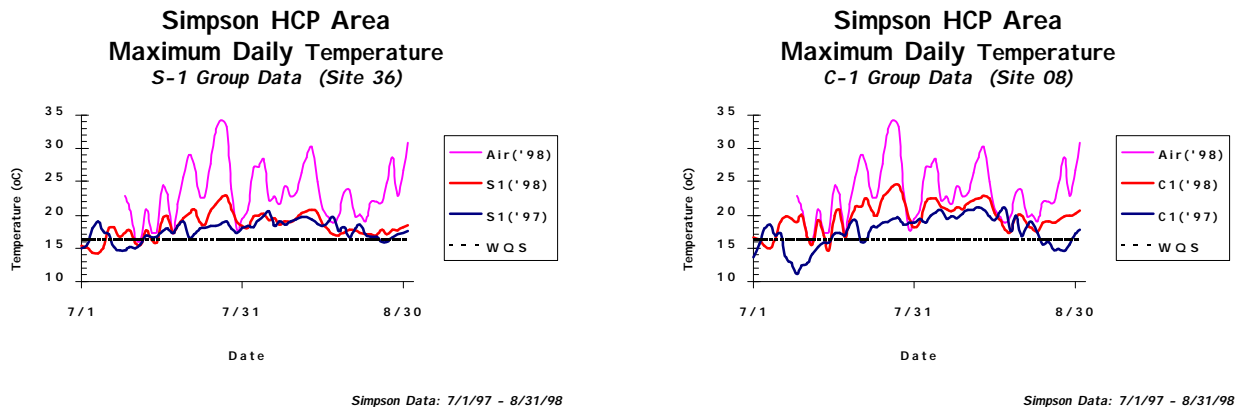
### Critical Temperature Conditions

Estimates for streamflow, loading, and water quality parameters need to be taken into account in development of the TMDL. The analysis demonstrating the relationship of channel and riparian conditions to solar radiation loads requires a framework for identifying critical conditions. Based on historical data for the Wynoochee River (*Figure 8-6*), the critical period used for the analysis is mid-July. This represents the time frame for which solar radiation is highest when the earliest summer maximum water temperatures were observed. This time frame is also consistent with water temperature data collected by Simpson (*Figure 8-7*).

**Figure 8-6.** Wynoochee River Summer Water Temperatures



**Figure 8-7.** Simpson HCP Area Summer Water Temperatures



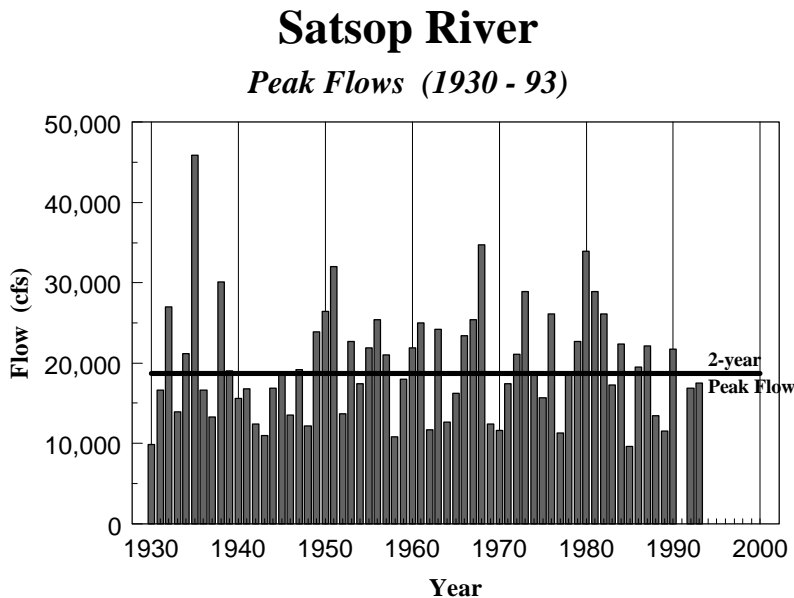
Streamflow estimates were identified using data from the USGS gage on the Satsop River near Satsop. Water yield for the 7-day low flow, 2-year recurrence interval (7Q2), which is also associated with the highest water temperatures observed at the gage, was used as a starting point. This represents a conservative approach and can be refined as additional flow data is collected in the Simpson HCP area. The same conservative

approach was used to identify parameters for calculation of solar radiation load (e.g. cloud cover) and water quality (e.g. air temperature, upstream water temperature, etc). Given the importance of stream type in evaluating critical conditions, information will be collected by Simpson to characterize riparian and channel conditions in the HCP area.

### **Annual Variability and Sediment**

It is important to discuss the annual variability of peak flows and its effect on sediment delivery. USGS (1971) described sediment yield in the Chehalis basin. Consistent with sediment studies in other areas, the report noted that the greatest percentage of sediment transport occurred during peak flows. Figure 8-8 shows the variation in peak flows for the Satsop River.

**Figure 8-8.** Satsop River Peak Flow History



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## **Appendix H: Watershed Analysis Prescriptions**

The Washington State watershed Analysis process is an attempt to implement a basin-wide approach to regulating the environmental aspects of forest practice regulation. A team of scientific experts, contributed from landowners, Indian Tribes, Washington Department of Natural Resources, the Washington Department of Fish and Wildlife, and other interested parties performs a scientific analysis of watershed processes operating in the basin. Modules address: Mass Wasting, Surface Erosion (from road and hillslopes, hydrology, Riparian issues, stream channel geomorphology, fish habitat, and public works in the watershed. Results of the analysis are given to a landowner-led prescriptions team, with participants from interested parties, which crafts specific prescriptions for forest practices to address the specific issues identified for the particular watershed.

Attached are the prescriptions developed for the three watershed analyses that have been completed in the Plan Area: Kennedy Creek, West Satsop, and the South Fork Skokomish. The prescriptions are summarized in Section 6.2.5 of the Plan.

WAU: Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #1 (includes Mass Wasting Map Unit's 1a, 1b, 3d and 10b).

**Situation sentence for the area:**

Coarse and fine sediment from mass wasting events associated with roads, timber harvest and natural processes has been, currently is, and will continue to be delivered to Kennedy Creek, Schneider Creek, Perry Creek and Helser (Holly) creek as well as to Eld Inlet.

Coarse sediment deposition reduces and degrades summer rearing and winter refuge habitats; fine sediment deposition degrades spawning habitat.

**Triggering Mechanism :**

Primary - roads intersect springs/seeps; roads concentrating surface runoff; destabilized slopes become saturated; root strength is lost in areas where springs/seeps are found or in areas where perched water tables are present.

Secondary - removal of vegetation and disturbance of the duff layer in seeps/spring areas.

**Rule call for management prescriptions :** Prevent and Avoid

**Field observations :** Refer to "Appendix 4.A" for specific comments/observations regarding triggers for each sub-unit.

**Prescriptions :**

**Road Construction:**

Option #1 - No road construction across these Mass wasting areas.

Option #2 - Construction of temporary or permanent road must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0 for Level 2 Mass Wasting). The following issues will be addressed: drainage, end haul, sidecast, road location, cut and fill slopes and others that may be appropriate for the specific location.

**Road Maintenance:**

Deals with existing roads and or those roads that will be receiving heavy haul.

Active/Inactive Roads - Simpson and The Department of Natural Resources will inventory all roads within these mass wasting areas and submit a road maintenance plan prior to July 1, 1996 which corrects all drainage deficiencies. Plans to be reviewed annually to assess priorities. Corrections will be done prior to receiving heavy haul.

Other landowners \*\* will be required to inventory their road drainage deficiencies within these mass wasting units that occur on their contiguous parcels associated with the proposed forest practice and submit a plan approved by DNR Forest Practices to deal with those deficiencies prior to receiving an approved Forest Practice application.

Orphaned Roads- Landowner plans shall be developed and implemented at the time the adjacent area is harvested. The plan will include all orphaned roads within the mass wasting unit and be developed in cooperation with tribes and other affected government agencies.

**Harvesting:**

No broadcast burning will be allowed in these mass wasting areas.

Option #1 - No harvest activities shall occur within the identified mass wasting unit.

Option #2 - Landowner \*\* inventories and eliminates harvest activities within 25 feet of seeps and wet areas .

Option #3 - Landowner \*\* identifies on the ground all the seeps and wet areas within their proposed activity area and develops a harvest plan for harvest within the 25 foot buffer that addresses the deliverability of sediment caused by loss of adequate root strength and disturbance to the duff layer .

Option #4 - Harvesting within these mass wasting area must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0).

***Justification for prescriptions :***

Roads: Correcting road drainage problem addresses triggering mechanisms.

Harvesting: Protecting root strength in areas of seeps and springs and or buffering type four and five waters ( see Harvesting option #3) addresses mass wasting concerns by acting as a filtering and anchoring system to reduce the potential delivery of sediment to type three waters.

\*\* Landowners need to have the necessary expertise to address the triggering mechanism, otherwise they will need to consult with a qualified specialist to develop a plan that prevents or avoids the triggering mechanism.

WAU: Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #2 (includes Mass Wasting Map Unit's 2 and 3c).

**Situation sentence for the area:**

Coarse and fine sediment from mass wasting events associated with existing roads and roads constructed on slopes between 30 and 50 percent delivered to Kennedy Creek

**Triggering Mechanism :** Roads intersect springs/seeps concentrating surface runoff.

**Rule call for management prescriptions :** Prevent and Avoid

**Field observations :** Refer to "Appendix 4.A" for specific comments/observations regarding triggers for each sub-unit.

**Prescriptions :**

**Road Construction:**

Option #1 - No road construction across these areas.

Option #2 - Construction of temporary or permanent roads must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0 for Level 2 Mass Wasting). The following issues will be addressed: drainage, end haul, sidecast, road location, cut and fill slopes and others that may be appropriate for the specific location.

**Road Maintenance:**

Deals with existing roads and or those roads that will be receiving heavy haul.

Active/Inactive Roads - Simpson and The Department of Natural Resources will inventory all roads within these mass wasting areas and submit a road maintenance plan prior to July 1, 1996 which corrects all drainage deficiencies. Plans to be reviewed annually to assess priorities. Corrections will be done prior to receiving heavy haul.

Other landowners \*\* will be required to inventory their road drainage deficiencies within these mass wasting units that occur on their contiguous parcels associated with the proposed forest practice and submit a plan approved by DNR Forest Practices to deal with those deficiencies prior to receiving an approved Forest Practice application.

**Harvesting:**

Not identified as a triggering mechanism.

***Justification for prescriptions :***

Roads: Correcting road drainage problem addresses triggering mechanisms.

WAU: Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #3 (includes Mass Wasting Map Unit's 4c and 4d).

***Situation sentence for the area:***

Coarse and fine sediment from mass wasting events associated with roads, timber harvest and natural processes has been delivered to Kennedy Creek, Schneider Creek, Summit Lake and Perry Creek. Debris flows and dam break floods can occur on steep tributaries greater than 10 degrees or 18 percent slope.

Coarse sediment deposition reduces and degrades summer rearing and winter refuge habitats; fine sediment deposition degrades spawning habitat.

***Triggering Mechanism :***

Primary - Road cut banks and loss of root strength in areas where seeps and springs are found.

Secondary - removal of vegetation and disturbance of the duff layer in seeps/spring areas.

***Rule call for management prescriptions :*** Prevent and Avoid

***Field observations :*** Refer to "Appendix 4.A" for specific comments/observations regarding triggers for each sub-unit.

***Prescriptions :***

**Road Construction:**

Option #1 - No road construction in the mass wasting area.

Option #2 - Construction of temporary or permanent roads must be designed by an approved specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0 for Level 2 Mass Wasting). The following issues will be addressed: drainage, end haul, sidecast, road location, cut and fill slopes and others that may be appropriate for the specific location.

**Road Maintenance:**

Deals with existing roads and or those roads that will be receiving heavy haul.

Active/Inactive Roads - Simpson and The Department of Natural Resources will inventory all roads within these mass wasting areas and submit a road maintenance plan prior to July 1, 1996

which corrects all drainage deficiencies and stabilization of unstable cut banks associated with springs and seeps. Plans to be reviewed annually to assess priorities. Corrections will be done prior to receiving heavy haul.

Other landowners \*\* will be required to inventory their road drainage deficiencies within these mass wasting units that occur on their contiguous parcels associated with the proposed forest practice and submit a plan approved by DNR Forest Practices to deal with those deficiencies prior to receiving an approved Forest Practice application (this includes stabilization of unstable cut banks associated with springs and seeps).

**Harvesting:**

No broadcast burning will be allowed within the mass wasting units.

Option #1 - No harvest activities shall occur within the identified mass wasting unit.

Option #2 - Landowner \*\* inventories and eliminates harvest activities within 25 feet of seeps and wet areas. In addition, no harvesting will take place within 25 feet (horizontal distance) of the over steepened (greater than 65%) portion of the stream bank or at the grade break which ever comes first. No broadcast burning within the mass wasting unit.

Option #3 - Landowner \*\* identifies on the ground all the seeps, wet areas and over steepened portions of the stream bank within their proposed harvest activity and develops a harvest plan for harvest within the 25 foot buffer that addresses the deliverability of sediment caused by loss of adequate root strength and disturbance to the duff layer .

Option #4 - Harvesting within these mass wasting area must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0).

***Justification for prescriptions :***

Roads: Correcting road drainage problem and avoiding over steepened areas within the mass wasting unit will avoid the triggering mechanisms.

Harvesting: Protecting root strength in areas of seeps and springs and or buffering type four and five waters addresses mass wasting concerns by acting as a filtering and anchoring system to reduce the potential delivery of sediment to type three waters. The 65% used to define the over steepened stream banks is based on the DNR soil survey information.

\*\* Landowners need to have the necessary expertise to address the triggering mechanism, otherwise they will need to consult with a qualified specialist to develop a plan that prevents or avoids the triggering mechanism.

WAU: Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #4 (includes Mass Wasting Map Unit 5c).

**Situation sentence for the area:**

Coarse and fine sediment from mass wasting events (on steep slopes greater than or equal to 35 percent) associated with roads, timber harvest and natural processes has been delivered to Kennedy Creek and Perry Creek.

Coarse sediment deposition reduces and degrades summer rearing and winter refuge habitats; fine sediment deposition degrades spawning habitat.

**Triggering Mechanism :**

Primary - Loss of root strength in areas where seeps and springs are found, removal of vegetation and disturbance of the duff layer in seeps/spring areas.

Secondary - Surface runoff concentrates on road fill or sidecast material.

**Rule call for management prescriptions :** Prevent and Avoid

**Field observations :** Refer to “Appendix 4.A” for specific comments/observations regarding triggers for each sub-unit.

**Prescriptions :**

**Road Construction:**

Option #1 - No road construction across these Mass wasting areas.

Option #2 - Construction of temporary or permanent road must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0 for Level 2 Mass Wasting). The following issues will be addressed: drainage, end haul, sidecast, road location, cut and fill slopes and others that may be appropriate for the specific location.

**Road Maintenance:**

Deals with existing roads and or those roads that will be receiving heavy haul.

Active/Inactive Roads - Simpson and The Department of Natural Resources will inventory all roads within these mass wasting areas and submit a road maintenance plan prior to July 1, 1996 which corrects all drainage deficiencies and stabilization of fill slopes that are saturated or destabilized by surface water concentrations. Plans to be reviewed annually to assess priorities. Corrections will be done prior to receiving heavy haul.

Other landowners \*\* will be required to inventory their road drainage deficiencies within these mass wasting units that occur on their contiguous parcels associated with the proposed forest practice and submit a plan approved by DNR Forest Practices to deal with those deficiencies prior to receiving an approved Forest Practice application (this includes stabilization of unstable fill slopes that are saturated or destabilized).

**Harvesting:**

Option #1 - No harvest activities shall occur within the identified mass wasting unit.

Option #2 - Landowner \*\* inventories and eliminates harvest activities within 25 feet of seeps, headwalls and wet areas. In addition, no harvesting will take place on the over steepened (greater than 65%) slopes within 25 feet (horizontal distance) of the stream bank or at the grade break which ever comes first. No broadcast burning within the mass wasting unit.

Option #3 - Landowner \*\* identifies on the ground all the seeps, headwalls, wet areas and over steepened portions of the stream bank within their proposed harvest activity and develops a harvest plan for harvest within the 25 foot buffer that addresses the deliverability of sediment caused by loss of adequate root strength and disturbance to the duff layer .

Option #4 - Harvesting within these mass wasting area must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0).

***Justification for prescriptions :***

Roads: Road maintenance will prevent surface water from saturating fill and sidecast material and thus avoid the potential for a mass wasting event associated with road fill and sidecast material.

Harvesting: Protecting root strength in areas of seeps and springs and or buffering type four and five waters addresses mass wasting concerns by acting as a filtering and anchoring system to reduce the potential delivery of sediment to type three waters. The 65% used to define the over steepened stream banks is based on the DNR soil survey information.

\*\* Landowners need to have the necessary expertise to address the triggering mechanism, otherwise they will need to consult with a qualified specialist to develop a plan that prevents or avoids the triggering mechanisms.

WAU: Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #5 (includes Mass Wasting Map Unit 6b).

***Situation sentence for the area:***

Coarse and fine sediment from mass wasting events associated with roads, timber harvest on slopes greater than or equal to 50% can be delivered to Kennedy Creek and Perry Creek.

Coarse sediment deposition reduces and degrades summer rearing and winter refuge habitats; fine sediment deposition degrades spawning habitat.

***Triggering Mechanism :***

Primary - Destabilization of slopes in areas of springs/seeps; where roads concentrate surface runoff; and removal of vegetation and disturbance of the duff layer.

Secondary - Loss of root strength in areas where springs/seeps are found or in areas where perched water tables are present.

***Rule call for management prescriptions :*** Prevent and Avoid

***Field observations :*** Refer to “Appendix 4.A” for specific comments/observations regarding triggers for each sub-unit.

***Prescriptions :***

**Road Construction:**

Option #1 - No road construction across these Mass wasting areas.

Option #2 - Construction of temporary or permanent road must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0 for Level 2 Mass Wasting). The following issues will be addressed: drainage, end haul, sidecast, road location, cut and fill slopes and others that may be appropriate for the specific location.

**Road Maintenance:**

Deals with existing roads and or those roads that will be receiving heavy haul.

Active/Inactive Roads - Simpson and The Department of Natural Resources will inventory all roads within these mass wasting areas and submit a road maintenance plan prior to July 1, 1996 which corrects all drainage deficiencies (this includes stabilization of unstable fill slopes that are saturated or destabilized). Plans to be reviewed annually to assess priorities. Corrections will be done prior to receiving heavy haul.

**Harvesting:**

No broadcast burning will be allowed within the mass wasting unit.

Option #1 - No harvest activities shall occur within the identified mass wasting unit.

Option #2 - Landowner \*\* inventories and eliminates harvest activities within a minimum of 25 feet of seeps and wet areas in headwall areas. No broadcast burning within the mass wasting unit. Prevent deposition of logging and road construction debris onto these head wall areas.

Option #3 - Landowner \*\* identifies on the ground all the seeps and wet areas in headwall areas within their proposed harvest activity and develops a harvest plan for harvest within the 25 foot buffer that addresses the deliverability of sediment caused by loss of adequate root strength and disturbance to the duff layer .

Option #4 - Harvesting within these mass wasting area must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0).

***Justification for prescriptions :***

Roads: Correcting road drainage problem and avoiding over steepened areas within the mass wasting unit will avoid the triggering mechanism.

Harvesting: Protecting root strength in areas of seeps and springs in head wall areas addresses mass wasting concerns by acting as an anchoring system to reduce the potential for mass wasting and delivery of sediment to type three waters.

\*\* Landowners need to have the necessary expertise to address the triggering mechanism, otherwise they will need to consult with an appropriate specialist to develop a plan that prevents or avoids the triggering mechanisms.

**WAU:** Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #6 (includes Mass Wasting Map Unit 7b).

***Situation sentence for the area:***

Coarse and fine sediment from mass wasting events associated with roads, timber harvest and natural processes on slopes greater than or equal to 35% has been, currently is and will continue to be delivered to Kennedy Creek, Summit Lake Helser(Holly) Creek, Eld Inlet, Schneider Creek and Perry Creek.

Coarse sediment deposition reduces and degrades summer rearing and winter refuge habitats; fine sediment deposition degrades spawning habitat.

Fine and coarse sediment delivered to Summit Lake has the potential to increase turbidity, introduces contaminants and degrade water quality.

Deposition of fine sediment into Eld Inlet causes siltation of shell fish beds and possibly siltation of nearby surf smelt spawning grounds.

***Triggering Mechanism :***

Primary - Removal of vegetation and disturbance of the duff layer allows erosion of exposed soils. Leave trees are subject to wind throw.

Secondary - Roads intersecting springs/seeps or where roads concentrate surface runoff and loss of root strength in areas where springs/seeps are found or in areas where perched water tables are present.

***Rule call for management prescriptions :*** Prevent and Avoid

***Field observations :*** Refer to “Appendix 4.A” for specific comments/observations regarding triggers for each sub-unit.

***Prescriptions :***

**Road Construction :**

Option #1 - Avoid areas with seeps, springs or headwalls.

Option #2 - Construction of temporary or permanent roads must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0 for Level 2 Mass Wasting). The following issues will be addressed: drainage, end haul, sidecast, road location, cut and fill slopes and others that may be appropriate for the specific location.

**Road Maintenance:**

Deals with existing roads and or those roads that will be receiving heavy haul.

Active/Inactive Roads - Simpson and The Department of Natural Resources will inventory all roads within these mass wasting areas and submit a road maintenance plan prior to July 1, 1996 which corrects all drainage deficiencies (this includes stabilization of unstable fill slopes that are saturated or destabilized). Plans to be reviewed annually to assess priorities. Corrections will be done prior to receiving heavy haul.

Other landowners \*\* will be required to inventory their road drainage deficiencies within these mass wasting units that occur on their contiguous parcels associated with the proposed forest practice and submit a road drainage and maintenance plan approved by DNR Forest Practices prior to receiving an approved Forest Practice application (this includes stabilization of unstable fill slopes that are saturated or destabilized).

**Harvesting:**

No broadcast burning will be allowed within the mass wasting unit.

Option #1 - No harvest activities shall occur within the identified mass wasting unit.

Option #2 - Landowner eliminates harvest activities within minimum of 66 feet on type three streams and 25 feet (horizontal distance) on type four and five streams. In addition landowner \*\* inventories and protects unstable areas that are on over steepened side slopes and are continuous to the stream channel.

Option #3 - Landowner \*\* identifies on the ground all the seeps, wet areas, unstable areas and over steepened portions of the stream bank within their proposed harvest activity and develops a harvest plan for harvest within the 25 foot buffer that addresses the deliverability of sediment caused by loss of adequate root strength and disturbance to the duff layer.

Option #4 - Harvesting within these mass wasting area must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0).

***Justification for prescriptions :***

Roads: Correcting road drainage problem and avoiding over steepened areas within the mass wasting unit will avoid the triggering mechanism.

Harvesting: Protecting root strength in areas of seeps and springs and or buffering streams addresses mass wasting concerns by acting as a filtering and anchoring system to reduce the potential delivery of sediment to type three waters.

\*\* Landowners need to have the necessary expertise to address the triggering mechanism, otherwise they will need to consult with a qualified specialist to develop a plan that prevents or avoids the triggering mechanism.

WAU: Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #7 (includes Mass Wasting Map Units 8b and 8c)

***Situation sentence for the area:***

Coarse and fine sediment from mass wasting events associated with roads, timber harvest and natural processes on slopes greater than or equal to 35% has been, currently is and will continue to be delivered to Kennedy Creek, Helser(Holly) Creek, Schneider Creek and Perry Creek.

Coarse sediment deposition reduces and degrades summer rearing and winter refuge habitats; fine sediment deposition degrades spawning habitat.

***Triggering Mechanism :***

Primary - Road construction destabilizes slopes in areas of springs/seeps; where roads concentrate surface runoff or where sidecast or fills become saturated during long duration storm events.

Secondary Loss of root strength in areas where springs/seeps are found or in areas where perched water tables are present.

***Rule call for management prescriptions :*** Prevent and Avoid

***Field observations :*** Refer to “Appendix 4.A” for specific comments/observations regarding triggers for each sub-unit.

***Prescriptions :***

**Road Construction :**

Drainage structures will be oversized to accommodate long term storm events.

Option #1 - No road construction will be allowed thru these mass wasting units.

Option #2 - Construction of temporary or permanent roads must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0 for Level 2 Mass Wasting). The following issues will be addressed: drainage, end haul, sidecast, road location, cut and fill slopes and others that may be appropriate for the specific location.

**Road Maintenance:**

Deals with existing roads and or those roads that will be receiving heavy haul.

Drainage structures will be oversized to accommodate long term storm events.

Active/Inactive Roads - Simpson and The Department of Natural Resources will inventory all roads within these mass wasting areas and submit a road maintenance plan prior to July 1, 1996 which corrects all drainage deficiencies (this includes stabilization of unstable fill slopes that are saturated or destabilized). Plans to be reviewed annually to assess priorities. Corrections will be done prior to receiving heavy haul.

Other landowners \*\* will be required to inventory their road drainage deficiencies within these mass wasting units that occur on their contiguous parcels associated with the proposed forest practice and submit a plan approved by DNR Forest Practices to deal with those deficiencies prior to receiving an approved Forest Practice application (this includes stabilization of unstable fill slopes that are saturated or destabilized).

**Harvesting:**

Option #1 - No harvest activities shall occur within the identified mass wasting unit.

Option #2 - Landowner \*\* inventories and eliminates harvest activities within 25 feet of seeps, headwalls and wet areas. In addition, no harvesting will take place within 25 feet (horizontal distance) on the over steepened (greater than 65%) portion of the stream bank or at the grade break which ever comes first. No broadcast burning within the mass wasting unit.

Option #3 - Landowner \*\* identifies on the ground all the seeps, headwalls, wet areas and over steepened portions of the stream bank within their proposed harvest activity and develops a harvest plan for harvest within the 25 foot buffer that addresses the deliverability of sediment caused by loss of adequate root strength and disturbance to the duff layer .

Option #4 - Harvesting within these mass wasting area must be designed by qualified Geologist and or other appropriate specialist (as defined in Standard Methodology for conducting Watershed Analysis, Version 2.0).

***Justification for prescriptions :***

Roads: Correcting road drainage problem and avoiding over steepened areas within the mass wasting unit will avoid the triggering mechanisms.

Harvesting: Protecting root strength in areas of seeps and springs and or buffering type four and five waters addresses mass wasting concerns by acting as a filtering and anchoring system to

reduce the potential delivery of sediment to type three waters. The 65% used to define the over steepened stream banks is based on the DNR soil survey information.

\*\* Landowners need to have the necessary expertise to address the triggering mechanism, otherwise they will need to consult with a qualified specialist to develop a plan that prevents or avoids the triggering mechanism.

WAU: Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #8 (includes Mass Wasting Map Unit 9b)

***Situation sentence for the area:***

Coarse and fine sediment from mass wasting events associated with timber harvest and natural processes on slopes greater than or equal to 30% can be delivered to Kennedy Creek, Helser(Holly) Creek, Eld Inlet, Schneider Creek and Perry Creek.

Coarse sediment deposition reduces and degrades summer rearing and winter refuge habitats; fine sediment deposition degrades spawning habitat.

Deposition of fine sediment into Eld Inlet causes siltation of shell fish beds and possible siltation of nearby surf smelt spawning grounds.

***Triggering Mechanism :***

Primary - Loss of root strength in areas where springs/seeps are found or in areas where perched water tables are present.

***Rule call for management prescriptions :*** Prevent and Avoid

***Field observations :*** Refer to “Appendix 4.A” for specific comments/observations regarding triggers for each sub-unit.

***Prescriptions :***

**Harvesting:**

Option #1 - No harvest activities shall occur within the identified mass wasting unit.

Option #2 - Landowner \*\* inventories and eliminates harvest activities within 25 feet of seeps and wet areas. In addition, no harvesting will take place within 25 feet (horizontal distance) on the over steepened (greater than 65%) portion of the stream bank or at the grade break which ever comes first.

Option #3 - Harvesting within these mass wasting area must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0).

***Justification for prescriptions :***

Harvesting: Protecting root strength in areas of seeps and springs and or buffering adjacent waters to addresses mass wasting concerns by acting as a filtering and anchoring system to reduce the potential delivery of sediment. The 65% used to define the over steepened stream banks is based on the DNR soil survey information.

\*\* Landowners need to have the necessary expertise to address the triggering mechanism, otherwise they will need to consult with a qualified specialist to develop a plan that prevents or avoids the triggering mechanism.

WAU: Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #9 (includes Mass Wasting Map Unit's 4c and above segment K-36).

***Situation sentence for the area:***

Coarse and fine sediment from mass wasting events associated with roads, timber harvest and natural processes on slopes and headwalls greater than or equal to 45% can be delivered to wetland segment K-36.

Sediment deposition causes local infilling of wetland ponds reducing and degrading summer rearing and winter refuge habitats.

***Triggering Mechanism :***

Primary - Slumps occur when slip planes on slopes above the road which have been destabilized by cutbanks become wet enough to overcome friction; and loss of root strength where springs/seeps are found or in areas where perched water tables are present.

Secondary - removal of vegetation and disturbance of the duff layer in seeps/spring areas.

***Rule call for management prescriptions :*** Minimize

***Field observations :*** Refer to "Appendix 4.A" for specific comments/observations regarding triggers for each sub-unit.

***Prescriptions :***

**Road Construction:**

Option #1 - Avoid areas with seeps, springs or headwalls.

Option #2 - Construction of temporary or permanent roads must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0 for Level 2 Mass Wasting). The following issues will be addressed: Drainage, end haul, sidecast, road location, cut and fill slopes and others that may be appropriate for the specific location.

**Road Maintenance:**

Deals with existing roads and or those roads that will be receiving heavy haul.

Active/Inactive Roads - Simpson and The Department of Natural Resources will inventory all roads within these mass wasting areas and submit a road maintenance plan prior to July 1, 1996 which corrects all drainage deficiencies (this includes stabilization of unstable cut banks associated with seeps and wet areas). Plans to be reviewed annually to assess priorities. Corrections will be done prior to receiving heavy haul.

Other landowners \*\* will be required to inventory their road drainage deficiencies within these mass wasting units that occur on their contiguous parcels associated with the proposed forest practice and submit a plan approved by DNR Forest Practices to deal with those deficiencies prior to receiving an approved Forest Practice application (this includes stabilization of unstable cut banks associated with seeps and wet areas).

**Harvesting:**

No broadcast burning will be allowed within the mass wasting unit.

Option #1 - No harvest activities shall occur within the identified mass wasting unit.

Option #2 - Landowner \*\* inventories and eliminates harvest activities within 25 feet of seeps and wet areas. In addition, no harvesting will take place within 25 feet (horizontal distance) of the over steepened (greater than 65%) portion of the stream bank or at the grade break which ever comes first. No broadcast burning within the mass wasting unit.

Option #3 - Landowner \*\* identifies on the ground all the seeps, wet areas and over steepened portions of the stream bank within their proposed harvest activity and develops a harvest plan for harvest within the 25 foot buffer that addresses the deliverability of sediment caused by loss of adequate root strength and disturbance to the duff layer .

Option #4 - Harvesting within these mass wasting area must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0).

***Justification for prescriptions :***

Roads: Correcting road drainage problems and avoiding over steepened areas within the mass wasting unit will avoid the triggering mechanisms.

Harvesting: Protecting root strength in areas of seeps and springs and or buffering type four and five waters addresses mass wasting concerns by acting as a filtering and anchoring system to

reduce the potential delivery of sediment to type three waters. The 65% used to define the over steepened stream banks is based on the DNR soil survey information.

\*\* Landowners need to have the necessary expertise to address the triggering mechanism, otherwise they will need to consult with a qualified specialist to develop a plan that prevents or avoids the triggering mechanism.

WAU: Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #10 (includes Mass Wasting Map Unit 9b adjacent to Totten Inlet and adjacent to an unevaluated segment that routes to P-3 through 1)

***Situation sentence for the area:***

Coarse and fine sediment from mass wasting events associated with timber harvest and natural processes on slopes greater than or equal to 30% can be delivered to Totten Inlet and Perry Creek.

Coarse sediment deposition reduces and degrades summer rearing and winter refuge habitats; fine sediment deposition degrades spawning habitat.

Deposition of fine sediment into Totten Inlet causes siltation of shell fish beds.

***Triggering Mechanism :***

Primary - Loss of root strength in areas where springs/seeps are found or in areas where perched water tables are present.

***Rule call for management prescriptions :*** Minimize

***Field observations :*** Refer to “Appendix 4.A” for specific comments/observations regarding triggers for each sub-unit.

***Prescriptions :***

**Harvesting:**

No broadcast burning will be allowed within the mass wasting unit.

Option #1 - No harvest activities shall occur within the identified mass wasting unit.

Option #2 - Landowner \*\* inventories and eliminates harvest activities within 25 feet of seeps and wet areas. In addition, no harvesting will take place within 25 feet (horizontal distance) on the over steepened (greater than 65%) portion of the stream bank or at the grade break which ever comes first.

Option #3 - Landowner \*\* identifies on the ground all the seeps, wet areas and over steepened portions of the stream bank within their proposed harvest activity and develops a harvest plan

for harvest within the 25 foot buffer that addresses the deliverability of sediment caused by loss of adequate root strength.

Option #4 - Harvesting within these mass wasting area must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0).

***Justification for prescriptions :***

Harvesting: Protecting root strength in areas of seeps and wet areas and or buffering adjacent waters to addresses mass wasting concerns by acting as a filtering and anchoring system to reduce the potential delivery of sediment. The 65% used to define the over steepened stream banks is based on the DNR soil survey information.

\*\* Landowners need to have the necessary expertise to address the triggering mechanism, otherwise they will need to consult with a qualified specialist to develop a plan that prevents or avoids the triggering mechanism.

**WAU:** Kennedy Creek

**Resource Sensitivity Number:** Mass Wasting #11 (includes Mass Wasting Map Unit 10b adjacent to Perry Creek segments P-3 through P-1)

***Situation sentence for the area:***

Coarse and fine sediment from mass wasting events associated with roads, timber harvest and natural processes on slopes greater than or equal to 35% can be directly delivered to Perry Creek and routed to Eld Inlet.

Coarse sediment deposition reduces and degrades summer rearing and winter refuge habitats; fine sediment deposition degrades spawning habitat.

Deposition of fine sediment into Eld Inlet causes siltation of shell fish beds.

***Triggering Mechanism :***

Primary - Roads intersect springs/seeps and concentrate surface runoff and loss of root strength in areas where springs/seeps are found or in areas where perched water tables are present.

Secondary - Removal of vegetation and disturbance of the duff layer allows for erosion of exposed soils.

***Rule call for management prescriptions :*** Minimize

***Field observations :*** Refer to “Appendix 4.A” for specific comments/observations regarding triggers for each sub-unit.

***Prescriptions :***

**Road Construction:**

Option #1 - No road construction within the identified mass wasting unit.

Option #2 - Construction of temporary or permanent road must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0 for Level 2 Mass Wasting). The following issues will be addressed: drainage, end haul, sidecast, road location, cut and fill slopes and others that may be appropriate for the specific location.

**Harvesting:**

Option #1 - No harvest activities shall occur within the identified mass wasting unit.

Option #2 - Landowner \*\* inventories and eliminates harvest activities within 25 feet of seeps and wet areas .

Option #3 - Landowner \*\* identifies on the ground all the seeps and wet areas within their proposed activity area and develops a harvest plan for harvest within the 25 foot buffer that addresses the deliverability of sediment caused by loss of adequate root strength and disturbance to the duff layer .

Option #4 - Harvesting within these mass wasting area must be designed by an appropriate specialist (as qualified in the Standard Methodology for conducting Watershed Analysis, Version 2.0).

***Justification for prescriptions :***

Roads: Future constructed roads will avoid the triggering mechanism.

Harvesting: Protecting root strength in areas of seeps and springs and or buffering type four and five waters addresses mass wasting concerns by acting as a filtering and anchoring system to reduce the potential delivery of sediment to type three waters.

\*\* Landowners need to have the necessary expertise to address the triggering mechanism, otherwise they will need to consult with a qualified specialist to develop a plan that prevents and avoids the triggering mechanism.

## **WEST SATSOP WATERSHED INTRODUCTION to PRESCRIPTIONS**

Prescriptions were developed by the Prescription Team as part of the watershed analysis conducted on the West Satsop Watershed Administrative Unit (WAU) # 220202, which is mostly in Grays Harbor County, with a small portion in Mason County. The prescriptions address each causal mechanism report individually as submitted by the Resource Assessment Module Leaders concerning road and hillslope erosion, mass wasting, public works, LWD recruitment potential, riparian shade and hydrologic response.

The Prescription Team met with the Module Leaders at “Hand-off” on November 16, 1995. The Prescription Team, respective Module Leaders, and others, outlined on page two, then met on November 28, 29, 30; December 1, 4, 5, 6, 7, 15, 1995; and January 18, 1996; and developed and wrote a draft of the attached prescriptions. Sub-team members subsequently did some follow-up work under the direction of the Prescription Team. The attached final draft of the prescriptions was reviewed and approved by all of the Prescription Team members.

### **General Comments and Recommendations**

1. Refer to “Forest Practice Rules and Regulations” for standard definitions and terms.
2. Work with local enhancement groups to obtain funding for implementing prescriptions and recommended enhancements outlined in Mass Wasting 1-7, Riparian 1-3, Shade 1-3, and Road Erosion 1-2, particularly for projects related to addressing causal mechanisms originating prior to current Forest Practice Rules and Regulations.
3. Utilize and expand on tabular and GIS data, which was compiled by the Module Leaders, during the risk assessment and prioritization phase of the prescriptions for Mass Wasting and Road Erosion.
4. In areas where mass wasting and riparian prescriptions overlap, the more restrictive prescription will apply.
5. The Prescription Team believes that these prescriptions will address impacts from forest practices on habitat needs of depressed stocks described in the Washington State Salmon and Steelhead Stock Inventory (SASSI, 1992) (See “Fish Habitat Assessment”, Appendix F, pages 1-2).
6. For Surface Erosion Prescriptions, special consideration shall be given for new road construction to prevent/minimize high rates of sediment delivery from new roads with high/moderate erosion hazard.

Resource Assessment Team and Prescription Team participants are as follows:

**RESOURCE ASSESSMENT**

**MODULE LEADER**

Jeffrey Clark  
Matt O'Connor  
Gary Graves  
Don Jordan  
Bruce Baxter  
Matt O'Connor  
Jeff Kirtland / Rhett Jackson

**MODULE**

Surface Erosion  
Mass Wasting  
Public Works  
Riparian  
Fish Habitat  
Channel  
Hydrology

**PRESCRIPTIONS**

**TEAM MEMBERS**

Tim Scherer  
Gary Schuyten  
Phil Peterson  
Charles Toal  
Gary Graves  
Bruce Baxter  
Lisa Lewis

**AFFILIATION**

Forest Engineer - Weyerhaeuser Co.  
Forester - Simpson Timber Co.  
Fisheries Biologist - Simpson Timber Co.  
Department of Ecology  
Forest Practices Forester - DNR - Ex-officio  
Fisheries Biologist - Quinalt Indian Nation  
U. S. Forest Service

**ADMINISTRATION**

Carolyn Johnston  
Susan Patch

Administrator - Weyerhaeuser Co.  
Facilitator - Weyerhaeuser Co.

**OBSERVERS / LANDOWNER REPRESENTATIVES**

Ken Trautman  
Keith Simmons  
Dave Backstrom  
Rick Schmeling  
Buck Muller

Forest Manager - Gleason-Skok, L. P.  
Forest Planning Manager - Simpson Timber Co.  
Forester - Simpson Timber Co.  
GIS Specialist / Forester - Simpson Timber Co.  
Landowner

The Prescription Team believes these prescriptions will protect and restore the public resources of fish and fish habitat, water, and capital improvements from adverse impacts of forest practices while maintaining a viable forest products industry in the West Satsop WAU.

The Assessment and Prescription writing processes for this diverse and complex watershed were uniquely challenging. Thanks to all of the participants for their valuable contributions.

Tim Scherer and Gary Schuyten  
West Satsop WSA Co-Team Leaders  
April 1, 1996

**INTRODUCTION to MASS WASTING PRESCRIPTIONS**  
**for**  
**MASS WASTING 1 through 7 (MW 1 - MW 7)**

The prescriptions for Mass Wasting use terminology and definitions which require further descriptions in order to properly interpret and apply them. Therefore, the following items must be understood and are part of these prescriptions:

1. In areas where riparian prescriptions overlap with mass wasting prescriptions, the more restrictive prescriptions will apply.
2. The channel migration zone is defined as the area that streams have recently occupied (in the last few years or less often decades), and would reasonably be expected to occupy again in the near future.
3. A geomorphological assessment report will address the geology and potential impacts from the proposed forest practice timber harvest activities on public resources due to decreased lateral root reinforcement, increased subsurface flow, decreased evapotranspiration, and mechanical disturbance of the soil.
4. A road construction or re-construction plan will address drainage, endhaul, sidecast, fills, waste areas, surfacing, temporary/permanent roads, seasonality, short/long-term maintenance, and field engineering. Road re-construction and maintenance applies to roads that were built or used for hauling forest products on or after 1974.
5. Maps A-2 & E-2 should be used in conjunction with these prescriptions. However, MWMUs 2, 3, 5, 8, 11, and 13 as shown on Map A-2, do not have prescriptions that apply to them.

The Prescription Team strongly encourages implementation of the recommendations, enhancements, and monitoring outlined in each prescription as well as the general comments and recommendations outlined in the “Introduction to Prescriptions”.

**PRESCRIPTION**

**Watershed:**

West Fork Satsop Watershed Administrative Unit

**Resource Sensitivity:** MW-1 (MWMU 1 & 10)

Large persistent deep-seated landslides with associated shallow rapid landslides on river escarpments with high delivery potential to streams.

**Situation Summary:**

Geomorphic Input:	Coarse and fine sediment
Time Frame:	Past and contemporary
Watershed Process:	Mass wasting
Hillslope Unit Locator:	MWMU 1 & 10 (See Map # A-2)
Activity:	Clear-cut logging and/or road construction
Conditions and Modifiers:	On unstable slopes
Channel Effects:	Burying portions of the channel, filling pools, introducing fine sediment to channel bed, introducing LWD
Locator:	GMU M1, M2 & M3 (See Map # E-2)
Resource Effects:	Degrading spawning and rearing habitat

**Triggering Mechanism(s):**

- Large persistent deep seated landslides: increased water delivery to landslide scarps, bodies and toes by road drainage; increased saturation of landslide bodies caused by reduced evapotranspiration following clear-cut harvest.
- Shallow rapid landslides primarily on LPD toes: increased water delivery to unstable slopes by road drainage; road sidecast fill slopes or cutslopes oversteepening unstable slopes; increased saturation of unstable slopes caused by reduced evapotranspiration following clear-cut harvest; decreased root-reinforcement of unstable LPD toe slopes caused by clear-cut timber harvest.

**Rule Call for Management Response:**

Delivered Hazard:	High
Resource Vulnerability:	High (Coarse sediment), Moderate (Fine sediment), High (LWD recruitment)
Rule Call:	Prevent & Avoid

**Notes:**

1. Headscarps and toes of Large Persistent Deep-Seated (LPD) landslides are much steeper slopes than landslide bodies and tend to be inherently unstable; these areas are susceptible to shallow rapid landslides. These areas are often easily identified in the field.
2. These MWMUs have a consistently high degree of hazard owing to the escarpment landforms that are extremely susceptible to mass wasting.

**Field Observations:**

- There are two levels of risk within these MWMUs, particularly in MWMU 10. The highest risk is associated with existing landslides that are active or have been active historically. A lower degree of risk exists in areas of this landform where no active or historically active landslides exist.
- In some cases ground based equipment has caused collection and channelization of water to adjacent unstable slopes.

**Management Objectives:**

Prevent activation or acceleration of LPDs caused by management activities in MWMUs 1 & 10 and retain the likelihood of future LWD.

**Prescriptions:**

Any forest management activity, such as ground based logging, road maintenance or road construction; in or adjacent to MWMUs 1 & 10 shall prevent interception, collection or routing water onto LPDs or other potentially unstable slopes; natural drainage patterns shall be maintained.

**Timber Management Activities:**

Timber harvest is not permitted in MWMUs 1 & 10 unless landowner develops a forest management operational plan, acceptable to DNR, supported by a geomorphological assessment report written by an appropriate Level 2 specialist, as qualified in the Standard Methodology for Conducting Watershed Analysis (see # 3 in “Introduction to Mass Wasting Prescriptions).

**Road Construction Related Activities:**

Road construction is not permitted on active shallow rapid landslides on unstable LPD toes in MWMUs 1 & 10. Road construction is permitted in other areas of MWMUs 1 & 10 if supported by a road construction plan, acceptable to DNR, and reviewed and approved by an appropriate Level 2 specialist, as qualified in the Standard Methodology for Conducting Watershed Analysis.

**Road Maintenance**

Landowner shall inventory all roads within the MWMUs 1 & 10 and submit a road maintenance plan prior to June 1, 1997, which addresses all drainage deficiencies. The plan will be prioritized based on assessed risk factors which identify potential for failure. The plan will be implemented on an annual basis starting in 1997. All identified deficiencies will be remediated by October, 1999. Plans will be reviewed annually with DNR to assess priorities.

**Road Re-construction**

Landowner shall develop a road re-construction plan, for roads that are potentially accelerating LPDs in MWMUs 1 & 10, designed by an appropriate Level 2 specialist, as qualified in the Standard Methodology for Conducting Watershed Analysis.

**Technical Rationale:**

- Soil disturbance from ground based equipment can re-route water.
- Active landslides are natural recruitment mechanisms for LWD.
- Concentration of water on active landslide scarps can increase likelihood of activation.
- BMPs identified in road maintenance plans can address road drainage related issues.
- Some areas in MWMUs 1 & 10 may be stable and can support forest management activities; however, site specific forest management plans are required to address variable stability of slopes.
- Boundaries of the MWMU include the active/inactive area and a marginal area which is best determined in the field.
- The geomorphologist will identify when evapotranspiration is an issue when Option 2 is used under Timber Management Activities.

**Recommendations from the Prescription Team for voluntary monitoring or enhancements:**

- Monitor major shifts in river location that may cause MWMUs 2 and 11 to meet the delivery criteria for MWMUs 1 & 10; i.e. non-delivering MWMUs not presently subject to prescriptions.
- Periodic observation of areas in and surrounding MWMU 1 & 10 (and 2 & 11) that have been harvested in order to detect new LPDs. This would increase confidence in prescriptions, ( positively or negatively.)
- Implement this prescription in conjunction with Riparian LWD prescription.

**PRESCRIPTION**

**Watershed:**

West Fork Satsop Watershed Administrative Unit

**Resource Sensitivity:** MW-2 (MWMU 4)

Shallow rapid landslides originating on mainstem river escarpments with high delivery potential to streams.

**Situation Summary:**

Geomorphic Input:	Coarse and fine sediment
Time Frame:	Past and present
Watershed Process:	Mass wasting
Hillslope Unit Locator:	MWMU 4 (See Map # A-2)
Activity:	Clear-cut logging and/or road construction
Conditions and Modifiers:	On unstable slopes
Channel Effects:	Introducing coarse and fine sediment to channel bed, introducing LWD
Locator:	GMU M2 (See Map # E-2)
Resource Effects:	Degrading spawning habitat

**Triggering Mechanism(s):**

Increased water delivery to inherently unstable steep slopes from road drainage or compacted soil surfaces; road sidecast fill slopes or cutslopes that oversteepen unstable slopes; increased saturation of unstable slopes caused by reduced evapotranspiration following clear-cut harvest; decreased root-reinforcement of unstable slopes and direct physical disturbance caused by clear-cut timber harvest.

**Rule Call for Management Response:**

Delivered Hazard:	High
Resource Vulnerability:	High (Coarse sediment), Moderate (Fine sediment & LWD)
Rule Call:	Prevent & Avoid

**Notes:**

1. These MWMUs encompass landforms that have unstable slopes located within them; substantial portions of areas within MWMU boundaries are not inherently unstable.
2. Most unstable areas in this MWMU can be identified in the field.

**Field Observations:**

- There is variability of potential deliverability.
- Indicators of instability: lack of old growth stumps and second-growth conifer; steep concave slopes greater than 70%; convex slopes immediately adjacent to river; vegetation indicators such as Devil's club, salmonberry and other wet soil condition indicators; and existing landslides in nearby areas with similar characteristics. Areas of instability are identifiable in the field based on these and other indicators.
- Inadequate road drainage and areas of sidecast practices on oversteepened slopes have created areas of potential failure.
- Small catchments above first order channels traversing steeper downslope areas (seeps) contribute to sub-surface flow. Some of these areas were observed on slopes less than 70%.

**Management Objectives:**

Prevent and avoid triggering mechanisms caused by management activities that initiate Shallow Rapid Landslides (SRs) and debris torrents (DTs) in MWMU 4, resulting in sediment delivery.

**Prescriptions:**

**Timber Harvest Activities**

No even age timber harvest on slopes in MWMU 4 which have indicators of instability and have the potential to deliver to a public resource. Even age harvest in areas lacking indicators of slope instability is allowed (See Field Observations). Partial timber removal will be permitted on unstable slopes if supported by written geomorphological assessment report designed by an appropriate Level 2 specialist, as qualified in the Standard Methodology for Conducting Watershed Analysis.

A Geomorphological Assessment Report shall address, at a minimum, the following items:

- Maintaining stocking levels to the degree necessary to maintain root reinforcement and stability of slope.
- Ground disturbance that could affect root strength, water channelization and local oversteepening

**Road Construction and Maintenance on Slopes Greater Than 65%**

Roads will be engineered (\*), constructed and maintained to prevent triggering SRs and DTs in MWMU 4 that will deliver to channels.

(\*)The proposed road construction plan shall be approved by an appropriate Level 2 specialist, as qualified in the Standard Methodology for Conducting Watershed Analysis.

Landowner shall inventory all roads within the MWMU 4 and submit a road maintenance plan prior to June 1, 1997, which addresses all drainage problems and potential landing and sidecast failures. The plan will be prioritized based on assessed risk factors which identify potential for failure. The plan will be implemented on an annual basis starting in

1997. All identified deficiencies will be remediated by October, 1999. Plans will be reviewed annually with DNR to assess priorities.

**Technical Rationale:**

- SR landslides are natural recruitment mechanisms for LWD in MWMU 4.
- Concentration of water on unstable slopes in MWMU 4 can increase the likelihood of landslides.
- Some areas in MWMU 4 may be stable and can support forest management activities; however, site specific forest management plans are required to address variable stability of slopes.
- Boundaries of the MWMU 4 include areas of variable slope stability which are best determined in the field.
- Non-road related SRs are the dominant process.

**Recommendations from the Prescription Team for voluntary monitoring or enhancements:**

- Periodical observation of areas in and surrounding MWMU 4 that have been harvested, in order to detect SRs.
- Recommend use of a slope stability model, such as LISA, in assessing the risk of slope failure due to the loss of root reinforcement and evapotranspiration from timber harvest in MWMU 4.
- Recommend monitoring of harvest units in MWMU 4 to assess whether loss of root strength or other slope disturbance has resulted in increased occurrence of mass wasting.
- Recommend monitoring of leave zones to assess whether they adequately reduce delivery of sediment from mass wasting.

**PRESCRIPTION**

**Watershed:**

West Fork Satsop Watershed Administrative Unit

**Resource Sensitivity:** MW-3 (MWMU 6 & 7)

Shallow rapid landslides and debris torrents originating on steep headwalls of tributary valleys and shallow rapid landslides on river escarpments with high delivery potential to streams.

**Situation Summary:**

Geomorphic Input:	Coarse and fine sediment
Time Frame:	Past and present
Watershed Process:	Mass wasting
Hillslope Unit Locator:	MWMU 6 & 7 (See Map # A-2)
Activity:	Clear-cut logging and/or road construction
Conditions and Modifiers:	On unstable slopes
Channel Effects:	Introducing fine sediment to channel bed
Locator:	GMU TM1 & TM2 (See Map # E-2)
Resource Effects:	Degrading spawning habitat

**Triggering Mechanism(s):**

Increased water delivery to inherently unstable steep slopes from road drainage or compacted soil surfaces; road sidecast fill slopes or cutslopes that oversteepen unstable slopes; increased saturation of unstable slopes caused by reduced evapotranspiration following clear-cut harvest; decreased root-reinforcement of unstable slopes and direct physical disturbance caused by clear-cut timber harvest.

**Rule Call for Management Response:**

Delivered Hazard:	Moderate
Resource Vulnerability:	High (Fine sediment), Moderate (Coarse sediment)
Rule Call:	Prevent & Avoid

**Notes:**

1. These MWMUs encompass landforms that have unstable slopes located within them; substantial portions of areas within MWMU boundaries are not inherently unstable.
2. Most unstable areas in this MWMU can be identified in the field.

**Field Observations:**

- Headwalls associated with MWMU 6 are typically greater than 70% slope and have the greatest potential for being the initiation point for debris torrents. In addition, streams in MWMU 6 have confined steep channels capable of sustaining debris torrents.
- Many areas of MWMU 6 that are not headwalls have characteristics similar to MWMU 7.
- Within MWMU 7 mass wasting has the following characteristics:
  - Size of landslides is small
  - Many landslides do not deliver. Those that do, deliver to Type 4 & 5 water.
  - Most of the MWMU as mapped does not produce landslides that threaten public resources
- Field identification of sites in MWMU 7 susceptible to mass wasting may be indicated by one or more of the following indicators of slope instability:
  - Wet soils and seeps
  - Presence of vegetation indicating high soil moisture
  - Areas of steep slopes typically greater than 70%
  - Lack of old-growth stumps and second-growth conifer
  - Obvious break in slope
  - Existing landslides in nearby areas with similar characteristics
  - In a few cases, road sidecast construction and misdirected road drainage have contributed to triggering of SR landslides and debris torrents.

**Management Objectives:**

Prevent sediment delivery to stream channels resulting from Shallow Rapid Landslides (SRs ) and debris torrents (DTs) caused by management activities in MWMUs 6 & 7.

**Prescriptions:**

**Timber Harvest Activities on slopes greater than 70%**

No even age timber harvest on slopes in MWMUs 6 & 7 which have indicators of slope instability and have the potential to deliver to a public resource. Even age harvest in areas lacking indicators of slope instability is allowed. (See Field Observations.) Partial timber removal will be permitted on unstable slopes if supported by written geomorphological assessment report designed by an appropriate Level 2 specialist, as qualified in the Standard Methodology for Conducting Watershed Analysis.

A Geomorphological Assessment Report shall address, at a minimum, the following items:

- Maintaining stocking levels to the degree necessary to maintain root reinforcement and stability of slope.

- Ground disturbance that could affect root strength, water channelization and local oversteepening

**Road Construction and Maintenance on Slopes Greater Than 65%**

Roads will be engineered (\*), constructed and maintained to prevent triggering SRs and DTs in MWMUs 6 & 7 that will deliver to channels.

(\*) The proposed road construction plan shall be approved by an appropriate Level 2 specialist, as qualified in the Standard Methodology for Conducting Watershed Analysis.

Landowner shall inventory all roads within the MWMUs 6 & 7 and submit a road maintenance plan prior to June 1, 1997, which addresses all drainage problems and potential landing and sidecast failures. The plan will be prioritized based on assessed risk factors which identify potential for failure. The plan will be implemented on an annual basis starting in 1997. All identified deficiencies will be remediated by October, 1999. Plans will be reviewed annually with DNR to assess priorities.

**Technical Rationale:**

- SR landslides are natural recruitment mechanisms for LWD in MWMUs 6 & 7.
- Concentration of water on unstable slopes in MWMUs 6 & 7 can increase the likelihood of landslides.
- Some areas in MWMUs 6 & 7 may be stable and can support forest management activities; however, site specific forest management plans are required to address variable stability of slopes.
- Boundaries of the MWMUs 6 & 7 include areas of variable slope stability which are best determined in the field.
- Mass Wasting Module Report P. 25, refers to placement of sidecast fill on slopes greater than 65% as a triggering mechanism for shallow rapid landslides.
- The majority of SRs in these MWMUs are likely triggered by delivery of road runoff to headwall areas.

**Recommendations from the Prescription Team for voluntary monitoring or enhancements:**

- Recommend use of a slope stability model, such as LISA, in assessing the risk of slope failure due to the loss of root reinforcement and evapotranspiration from timber harvest in MWMUs 6 & 7.
- Recommend monitoring of harvest units in MWMUs 6 & 7 to assess whether loss of root strength or other slope disturbance has resulted in increased occurrence of mass wasting.
- Recommend monitoring of leave zones to assess whether they adequately reduce delivery of sediment from mass wasting.

**PRESCRIPTION**

**Watershed:**

West Fork Satsop Watershed Administrative Unit

**Resource Sensitivity:** MW-4 (MWMU 9 & 12)

Large persistent deep-seated landslides and shallow rapid landslides on river escarpments in tributary valleys with high delivery potential to streams.

**Situation Summary:**

Geomorphic Input:	Coarse and fine sediment
Time Frame:	Past and contemporary
Watershed Process:	Mass wasting
Hillslope Unit Locator:	MWMU 9 & 12 (See Map # A-2)
Activity:	Clear-cut logging and/or road construction
Conditions and Modifiers:	On unstable slopes
Channel Effects:	Burying portions of the channel, filling pools, introducing fine sediment to channel bed
Locator:	GMU TG1, TG2, TL1, TL2, M1, M2, M3, M6 (See Map # E-2)
Resource Effects:	Degrading spawning and rearing habitat

**Triggering Mechanism(s):**

- Large persistent deep seated landslides: increased water delivery to landslide scarps, bodies and toes by road drainage; increased saturation of landslide bodies caused by reduced evapotranspiration following clear-cut harvest.
- Shallow rapid landslides: increased water delivery to unstable slopes by road drainage; road sidecast fill slopes or cutslopes oversteepening unstable slopes; increased saturation of unstable slopes caused by reduced evapotranspiration following clear-cut harvest; decreased root-reinforcement of unstable slopes caused by clear-cut timber harvest.

**Rule Call for Management Response:**

Delivered Hazard:	High for MWMU 9, Moderate for MWMU 12
Resource Vulnerability:	Moderate (Coarse sediment), Moderate (Fine sediment)
Rule Call:	Prevent and Avoid for MWMU 9, Minimize for MWMU 12

**Notes:**

1. Headscarps and toes of LPD landslides are much steeper slopes than landslide bodies and tend to be inherently unstable; these areas are susceptible to shallow rapid landslides. These areas are often easily identified in the field.
2. The areas within these MWMUs have an inconsistent degree of hazard owing to the variable slopes of tributary escarpments and variable valley width and configuration of terraces. Areas with lesser hazard can often be identified in the field.
3. Criteria for moderate vulnerability call are the deliverability of fine sediment to M1, M2, M3 & M6, and deliverability of coarse sediment to TG1, TG2, TL1, TL2. Deliverability of coarse sediment to M1, M2, M3 & M6 GMUs is insignificant.

**Field Observations:**

- The size and severity of SRs and LPDs in MWMU 9 is significantly greater than in MWMU 12.
- Many landslides in MWMU 9 are of a natural origin. Where roads are present they have a high likelihood of triggering mass wasting.
- Erosion of stream banks has triggered a significant number of landslides in MWMU 9.

**Management Objectives:**

Prevent activities which will initiate triggering mechanisms causing Mass Wasting in MWMU 9 and minimize these activities in MWMU 12.

**Prescriptions:**

These prescriptions apply to both MWMU 9 and MWMU 12. In MWMU 12, substitute “minimize” for “prevent” or “avoid”.

**Timber Management Activities:**

Timber harvest is not permitted in MWMUs 9 & 12 unless landowner develops a forest management operational plan, acceptable to DNR, supported by a geomorphological assessment report written by an appropriate Level 2 specialist, as qualified in the Standard Methodology for Conducting Watershed Analysis (see # 3 in “Introduction to Mass Wasting Prescriptions”).

A Geomorphological Assessment Report will address, at a minimum, the following:

1. Prevent increased routing of water from management activities to hillslopes.
2. Topographic breaks shall be used to establish timber management boundaries.
3. Riparian leave areas shall be left adjacent to all streams to avoid delivery.
4. Leave areas shall be left where hillslopes would deliver sediment from mass wasting directly to channels.

**Road Construction Activities:**

Road construction is not permitted, unless the road is fully engineered and designed to address the following issues:

- a. Prevent increased routing of water from management activities to hillslopes.
- b. Restrict placement of roads to main access draw crossings.
- c. No road sidecast on slopes greater than 50% slope.
- d. Design cutslopes, ditches, and drainages to prevent failure of slope banks and plugging of ditches, rerouting of water and subsequent mass failures.
- e. If road is temporary, it will be abandoned prior to October 1, unless otherwise authorized by DNR.
- f. If road is permanent, a long term maintenance plan will accompany the road design proposal.

Road construction on slopes greater than 50% shall be located by a forest engineer, and reviewed and approved by a qualified L2 specialist prior to Forest Practice Application submittal.

**Road Maintenance Activities**

Landowner shall inventory all roads within the MWMUs 9 & 12 and submit a road maintenance plan prior to June 1, 1997, which addresses all drainage deficiencies. The plan will be prioritized based on assessed risk factors which identify potential for failure. The plan will be implemented on an annual basis starting in 1997. All identified deficiencies will be remediated by October, 1999. Plans will be reviewed annually with DNR to assess priorities.

**Technical Rationale:**

- SR and LPD landslides are natural recruitment mechanisms for LWD, especially in MWMU 9.
- Concentration of water on unstable slopes in MWMUs 9 & 12 can increase the likelihood of landslides.
- BMPs identified in road maintenance plans can address road drainage and slope stabilization related issues.
- Some areas in MWMU 12 may be stable and can support forest management activities; however, site specific forest management plans are required to address variable stability of slopes.
- Boundaries of the MWMU 12 include areas of variable slope stability which are best determined in the field.
- The risk of forest road failure on new road construction can be significantly reduced by full engineering and designing.

**Recommendations from the Prescription Team for voluntary monitoring or enhancements:**

- Recommend use of a slope stability model, such as LISA, in assessing the risk of slope failure due to loss of root reinforcement and evapotranspiration from timber harvest in MWMUs 9 and 12.
- Recommend monitoring of harvest units in MWMUs 9 & 12 to assess whether loss of root strength or other slope disturbance has resulted in increased occurrence of mass wasting.
- Recommend monitoring of leave zones to assess whether they adequately reduce delivery of sediment from mass wasting.

**PRESCRIPTION**

**Watershed:**

West Fork Satsop Watershed Administrative Unit

**Resource Sensitivity:** MW-5 (MWMU 14, 15 & 17)

Shallow rapid landslides from terrace escarpments, bank erosion and channel migration over long periods of time with high delivery potential to streams.

**Situation Summary:**

Geomorphic Input:	Coarse and fine sediment
Time Frame:	Past and contemporary
Watershed Process:	Mass wasting and bank erosion
Hillslope Unit Locator:	MWMU 14, 15 & 17 (See Map # A-2)
Activity:	Clear-cut logging and/or road construction
Conditions and Modifiers:	On terraces, floodplains, stream banks or footslopes adjacent to channels.
Channel Effects:	Burying portions of the channel, filling pools with coarse sediment, introducing fine sediment to channel bed.,
Locator:	GMU TM1, TM2, TG1, TG2, TL1, TL2, M1, M2, M3, M6 (See Map # E-2)
Resource Effects:	Degrading spawning and rearing habitat

**Triggering Mechanism(s):**

Harvest of stream bank and floodplain forest stands, physical disturbance of streambanks by harvest activities or road construction, road construction or tractor yarding creating potential paths for over bank flow that could lead to channelized flow and erosion of terraces, road construction or yarding that could deliver runoff to stream banks or terrace escarpments, and placement of sidecast on road fillslopes on steep slopes.

**Rule Call for Management Response:**

Delivered Hazard:	Moderate
Resource Vulnerability:	High (Coarse sediment--M1, M2, M3, M6); Moderate (Coarse sediment--M5, TM1, TM2, TG1, TG2, TL1, TL2); High (Fine sediment-TM1); Moderate (Fine sediment--M1, M2, M3, M6, TM2, TG2, TL2)
Rule Call:	Prevent and Avoid (MWMU 14, MWMU 15 where adjacent to TM1 or TM2); Minimize (MWMU 15 where adjacent to TG1, TG2, TL1, TL2 and MWMU 17)

**Notes:**

1. The areas within these MWMUs have an inconsistent degree of hazard owing to variable valley width and potential for over bank flow, and configuration of terraces, channels and stream banks. Areas with lesser hazard can often be identified in the field.
2. Criterion for high vulnerability call for MWMU 15 adjacent to TM2 is the deliverability of fine sediment to TM1.

**Field Observations:**

- Stream channels are actively eroding their banks.
- In some areas stream channels have shifted and occupied portions of flood plain and low terraces; areas of flood plain and low terrace that are subject to this, can be identified in the field.
- Trees on stream banks are a component of bank stability.

**Management Objectives:**

Prevent (minimize in MWMU 15 where adjacent to TG1, TG2, TL1, TL2 and in MWMU 17) activation or acceleration of bank erosion and channel avulsion caused by management activities in MWMUs 14, 15 & 17 and retain the likelihood of future LWD recruitment.

**Prescriptions:**

These prescriptions apply to MWMUs 14, 15 & 17. In MWMU 15 where adjacent to TG1, TG2, TL1, TL2 and in MWMU 17, substitute “minimize” for “prevent” or “avoid”.

**Federal Lands:**

Projects and activities shall be consistent with the Aquatic Conservation Strategy. These objectives are outlined in the Record of Decision (ROD), B-11 and C-31.

Prescribed widths of Riparian Reserves apply until a site specific analysis is conducted and described and the rationale for final Riparian Reserve boundaries is presented through the appropriate NEPA decision-making process, ROD C-30

On federal lands, a detailed analysis of existing and potential erosion sites has been completed. Using this, and other related information, develop an Access and Travel Management Plan (ATM). Submit the ATM plan to District Ranger for review and approval. This plan will outline activities to prevent high delivery of fine sediments from road surfaces and cut banks. The ATM plan shall be submitted by June 1, 1997.

**Non-Federal Lands:**

**Timber Harvest Activities:**

Timber harvest is permitted within the channel migration zone (\*) in MWMUs 14, 15 & 17, to the extent provided for as described in the appropriate riparian prescription.

**Road Construction Activities**

Permanent road construction shall not occur in MWMUs 14, 15 & 17 except for perpendicular crossing of the channel migration zone (\*). If road construction is proposed, it will be fully engineered, designed and supported by a road construction plan which is approved by an appropriate Level 2 specialist, as qualified in the Standard Methodology for Conducting Watershed Analysis.

**Road Maintenance Activities**

Landowner shall inventory all roads within the MWMUs 14, 15 & 17 and submit a road maintenance plan prior to June 1, 1997, which addresses all drainage deficiencies. The plan will be prioritized based on assessed risk factors which identify potential for failure. The plan will be implemented on an annual basis starting in 1997. All identified deficiencies will be remediated by October, 1999. Plans will be reviewed annually with DNR to assess priorities.

(\*) : See “Introduction to Mass Wasting Prescriptions”

**Technical Rationale:**

- Best Management Practices, as identified in approved road maintenance plans will reduce and prevent high rates of sediment delivery to the channel network.
- Channel migration zones are natural recruitment areas for LWD
- BMPs identified in road maintenance plans can address road drainage and slope stabilization related issues.
- Channel migration zone boundaries must be determined in the field.
- The risk of forest road failure on new road construction can be significantly reduced by full engineering and designing. Location of roads in channel migration zone could lead to negative impacts to stream habitat by restricting flood plain and channel migration.

**Recommendations from the Prescription Team for voluntary monitoring or enhancements:**

- Channel pattern in some portions of the CMZ in MWMU 14 have been mapped from aerial photographs by the Channel Analyst. It is recommended that this information be used as a historical reference and updated when determining management options.

- For Federal lands, implement road decommissioning and stabilization as identified in the Access and Travel Management Plan.

**PRESCRIPTION**

**Watershed:**

West Fork Satsop Watershed Administrative Unit

**Resource Sensitivity:** MW-6 (MWMU 16 & 18)

Shallow rapid landslides and debris torrents originating on steep slopes with high delivery potential to streams.

**Situation Summary:**

Geomorphic Input:	Coarse and fine sediment
Time Frame:	Past and present
Watershed Process:	Mass wasting
Hillslope Unit Locator:	MWMU 16 & 18 (See Map # A-2)
Activity:	Clear-cut logging and/or road construction
Conditions and Modifiers:	On unstable slopes (>65%)
Channel Effects:	Filling pools and increasing bed mobility
Locator:	GMU M4, M5, TC1 & TC2 (See Map # E-2)
Resource Effects:	Degrading spawning habitat and rearing habitat

**Triggering Mechanism(s):**

Increased water delivery to inherently unstable steep slopes from road drainage or compacted soil surfaces; road sidecast fill slopes or cutslopes that oversteepen unstable slopes; increased saturation of unstable slopes caused by reduced evapotranspiration following clear-cut harvest; decreased root-reinforcement of unstable slopes and direct physical disturbance caused by clear-cut timber harvest.

**Rule Call for Management Response:**

Delivered Hazard:	High (MWMU 18), Moderate (MWMU 16)
Resource Vulnerability:	Moderate (Coarse sediment)
Rule Call:	Prevent & Avoid (MWMU 18), Minimize (MWMU 16)

**Notes:**

1. These MWMUs encompass the Olympic Mountain landscape in the WAU, substantial portions of areas within the MWMUs may be significantly less unstable.
2. Over 80% of the inventoried mass wasting features were associated with roads or inner gorge slopes, suggesting that the majority of mass wasting hazards can be addressed through modified road construction & maintenance practices and by avoiding clear-cut harvest on easily-identified inner gorge slopes.

**Field Observations:**

- See Note #1
- If road related landslides were eliminated there would likely be larger areas in which management related landslides would be significantly less likely.
- Road construction was completed in these MWMUs prior to 1974. Road construction began in late 1940's, with majority of roads being built in 60's and 70's. Roads were fully engineered. However, BMPs prior to 1970 allowed 100% sidecast construction with some burying of organic debris in road fills and landings.
- Many additional road sidecast sites show signs of instability, such as tension cracks.
- The natural instability of slopes in portions of MWMUs 16 & 18 indicate that significant mass wasting have and will occur in the absence of active forest management.
- With respect to historical mass wasting sites not related to roads, mass wasting inventory data indicate that significantly greater proportion of these mass wasting sites originate in areas with map slopes greater than 80% and in inner gorge areas.
- With respect to historical mass wasting sites not related to roads, mass wasting inventory data indicate that hazard of triggering a DT is restricted to convergent topography near channel heads.

**Management Objectives:**

Prevent in MWMU 18 and minimize in MWMU 16, activation or acceleration of SRs and DTs caused by management activities and retain the likelihood of future LWD recruitment.

**Prescriptions:**

These prescriptions apply to MWMUs 16 & 18. In MWMU 16, substitute "minimize" for "prevent" or "avoid".

**Federal Lands:**

Projects and activities shall be consistent with the Aquatic Conservation Strategy. These objectives are outlined in the Record of Decision (ROD), B-11 and C-31.

Prescribed widths of Riparian Reserves apply until a site specific analysis is conducted and described and the rationale for final Riparian Reserve boundaries is presented through the appropriate NEPA decision-making process, ROD C-30

On federal lands, a detailed analysis of existing and potential erosion sites has been completed. Using this, and other related information, develop an Access and Travel Management Plan (ATM). Submit the ATM plan to District Ranger for review and approval. This plan will outline activities to prevent high delivery of fine sediments from road surfaces and cut banks. The ATM plan shall be submitted by June 1, 1997.

**Non-Federal Lands:**

Timber Harvest Activities

Timber harvest plan will be developed on sites which are on slopes greater than 80%, inner gorge areas, or convergent topography near channel heads, which addresses the following:

- Maintain root reinforcement necessary to ensure slope stability.
- Partial timber removal.
- Avoiding ground disturbance that could affect root strength and water channelization and local oversteepening.
- Designing harvest units to avoid creating the need for additional roads due to leave tree areas.
- The harvest plan will be reviewed and approved by a qualified L2 specialist prior to permit submittal.

Road Construction and Reconstruction Activities on slopes greater than 65%

Road construction and reconstruction is not permitted, unless the road is fully engineered, constructed and maintained to prevent triggering SRs and DTs that will deliver to channels, including but not limited to the following:

- a. Keep water in native drainages and route drainage water to existing channels.
- b. Road sidecast construction is not permitted.
- c. Design cutslopes, ditches, and drainages to prevent failure of slope banks and plugging of ditches, rerouting of water and subsequent mass failures.
- d. If road is temporary, it will be abandoned prior to October 1, unless otherwise authorized by DNR.
- e. If road is permanent, a long-term maintenance plan will accompany the road design proposal.
- f. Roads will be located by a forest engineer, and reviewed and approved by a qualified L2 specialist prior to permit submittal.

Road Maintenance Activities

Discontinue sidecasting when blading roads during maintenance, where sidecast materials could affect water quality such as concave slopes.

Landowner shall inventory, analyze and prioritize all roads within the MWMUs 16 & 18 and submit a road maintenance plan prior to June 1, 1997, which addresses all drainage deficiencies and abandonment and stabilization requirements. The plan will be prioritized based on assessed risk factors which identify potential for failure. The plan will be implemented on an annual basis starting in 1997. All identified deficiencies will be remediated by October, 1999. Plans will be reviewed annually with DNR to assess priorities.

**Technical Rationale:**

- The module report for Mass Wasting, P. 38, refers to failure site: unrelated to roads are generally on slopes greater than 80%; the reduction of root strength resulting from harvest is the primary effect of management that increases the likelihood of slope failure.

**Recommendations from the Prescription Team for voluntary monitoring or enhancements:**

- Recommend use of a slope stability model, such as LISA, in assessing the risk of slope failure due to timber harvest in MWMUs 16 & 18.
- Recommend monitoring of harvest units in MWMUs 16 & 18 to assess whether loss of root strength or other slope disturbance has resulted in increased occurrence of mass wasting.

**PRESCRIPTION**

**Watershed:**

West Fork Satsop Watershed Administrative Unit

**Resource Sensitivity:** MW-7

Loss of a long-term supply of LWD to Type 4 & 5 streams results in long-term stream channel erosion, streambank erosion, streamside mass wasting where steep slopes abut the stream channel, and a loss of sediment storage producing increased delivery of fine sediment to vulnerable channel segments.

**Situation Summary:**

Geomorphic Input:	Fine sediment and coarse sediment subject to attrition and producing fine sediment
Time Frame:	Past, present and future
Watershed Process:	Erosion of bed and banks, streamside landslides
Locator:	GMU's TM3, TM4, TG3, TL2, TL3, TL4, TC3, TC4 (See Maps #s E-1 & E-2)
Activity:	Harvesting riparian forest stands
Conditions and Modifiers:	Channels previously disturbed by clear-cut logging, increasing abundance of LWD and extending the length of the channel network as channel heads migrate upstream nearer drainage divides.
Channel Effects:	Reduced sediment storage and routing sediment
Resource Effects:	Degrading spawning and rearing habitat

**Triggering Mechanism(s):**

Prior harvest of riparian forest stands, reducing or eliminating LWD recruitment over the past 30 to 50 years, creating conditions where functional LWD is in an advanced state of decay and is not being replaced by recruitment of coniferous LWD from second growth stands. Declining LWD function indicates that stream channels, banks and hillslopes adjacent to streams are expected to “unravel” over the coming decades if adequate LWD recruitment from maturing forest stands does not occur.

**Rule Call for Management Response:**

Delivered Hazard:	Moderate (except TC3--High)
Resource Vulnerability:	Moderate (except TM3 & TM4--High)
Rule Call:	Minimize (except TM3 & TM4--Prevent & Avoid)

**Notes:**

1. Criteria for maintenance of LWD function should include recruitment of a variety of size classes of LWD and significant amounts with diameter  $\geq$  bankfull channel depth.

**Field Observations:**

- Woody debris in Type 4 and 5 stream channels traps and holds sediments. Trapping this sediment plays a major role in maintaining stability of channel sideslopes and preventing channel incision..
- There is significant difference in the transport of sediment due to much greater amount of woody debris in the stream. This woody debris lowers sediment delivery rates, by trapping, and storing sediment.

**Management Objectives:**

Maintain sediment storage and routing capacity of channel and minimize (prevent in TM3 & TM4) sideslope oversteepening.

**Prescriptions:**

These prescriptions apply to GMUs TM3, TM4, TG3, TL2, TL3, TL4, TC3, TC4. Substitute “minimize” for “prevent” or “avoid” in these GMUs, except in TM3 & TM4.

**Federal Lands:**

Projects and activities shall be consistent with the Aquatic Conservation Strategy. These objectives are outlined in the Record of Decision (ROD), B-11 and C-31.

Prescribed widths of Riparian Reserves apply until a site specific analysis is conducted and described and the rationale for final Riparian Reserve boundaries is presented through the appropriate NEPA decision-making process, ROD C-30

**Non-Federal Lands:**

On Type 4 waters, in GMUs described above, minimize (Prevent in TM3, TM4) removal or disturbance of current wood in stream channel and adjacent banks. In addition, utilize one of the following 3 options:

**Option 1**

Retain a minimum of 45 trees (conifers preferred) per 1000 feet of stream length, 12” + diameter, distributed along the stream in one of the following patterns:

- a. Uniformly.
- b. Clumped in areas of locally higher than average channel slope.
- c. One half clumped near tributary junctions and one half clumped in areas of locally higher than average channel slope.

**Option 2**

Up to 10 of the leave trees per 1000 feet of stream length as described in Option 1 may be harvested if functional conifer logs are strategically distributed in the stream channel on a one for one basis. Conifer logs will be a minimum of 12” on large end and 5 x channel width in length.

**Option 3**

Where streams are in proximity to an existing MWMU, use those prescriptions where they will provide equal or greater LWD recruitment as described in Option 1 or Option 2.

**Technical Rationale:**

- Woody debris in Type 4 and 5 streams traps and holds sediments, thereby, reducing sediment transport and increasing channel sideslope stability.
- Addressing type 4 waters will result in a low resource vulnerability.

**Recommendations from the Prescription Team for voluntary monitoring or enhancements:**

- Locate trees on windward side of stream.

## MW-1

**DESCRIPTION:** unmapped gorges and valley walls (MWMUs 1 & 2b) in otherwise flat topography

**Applicable MWMUs**

- 3 Alluvial valley bottoms
- 4 Glacial valley bottoms
- 5 Glacial and glaciofluvial terraces

**RULE CALL:** Minimize (ARS Map Unit 1a, which is on USFS land) or Prevent/Avoid (ARS Map Unit 1b, which is on the main stem)

**hazard delivery rating:** moderate

**resource vulnerability:** moderate (GMU 9, delivered indirectly or routed via GMU 12.1 or 12.2); high (GMU 1, 2, 6 or 7 routing via various pathways)

### SITUATION SUMMARY

- Input:** Coarse and fine sediment (*fine sediment in GMU 2, 7, 9 only*)
- Time Frame:** from past, present, and future
- Process:** mass wasting
- Activity:** associated with clearcut harvesting and roading on
- MWMU(s):** unmapped gorges and valley walls (MWMUs 1&2b) in otherwise low gradient topography (MWMU 3, 4, & 5)
- Channel Effects:** may cause channel avulsion, aggradation, increased depth of scour, loss of surface flow, increased pool spacing, loss of LWD function, and increased stream bank erosion causing
- Resource Effects:** lower reproductive success for fall spawning species, possibly delayed migration in dry years, stranding in isolated pools and/or death in the dry stream of juvenile salmonids, lower summer and winter survival, fewer large trout in rearing populations, fewer coho and cutthroat juveniles.

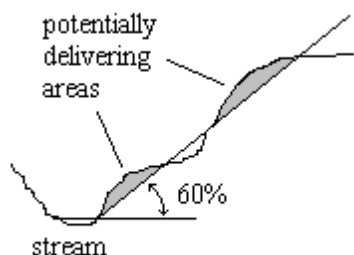
### TRIGGERING MECHANISM

see Causal Mechanism MW-2

### COMMENTS

Streams and terraces in this otherwise gentle topography create small versions of MWMUs 1 and 2b which are too small to have been mapped from air photos and need to be identified in the field. Once identified, these minor gorges and valley walls have the same causal mechanisms as MW-2.

The gorges and valley walls are delineated by sediment delivery potential to the streams which can be defined as all soils that lie above any 60% grade extending from any stream in MWMUs 3, 4, and 5 (*see sketch*).



Potentially unstable slopes within these gorges and valley walls are those areas with local slopes of at least 70%.

### **MANAGEMENT OBJECTIVES**

Identify potential hazard and delivery areas within this MWMU and avoid management activities that could initiate shallow rapid landslides on those areas.

### **PRESCRIPTIONS**

#### ***Public (federal) lands***

Projects and activities shall be consistent with the Aquatic Conservation Strategy. These objectives are outlined in the Record of Decision (ROD, B-11 and C-31).

Prescribed widths of Riparian Reserves apply until a site specific analysis is conducted and described and the rationale for final Riparian Reserve boundaries is presented through the appropriate NEPA decision-making process, ROD C-30.

On public lands, a detailed analysis of existing and potential erosion sites has been completed. Using this, and other related information, an Access and Travel Management Plan (ATM) was developed and submitted to the District Manager for review and approval. This plan outlines activities to prevent high delivery of fine sediments from road surfaces, cut banks, and fill slopes.

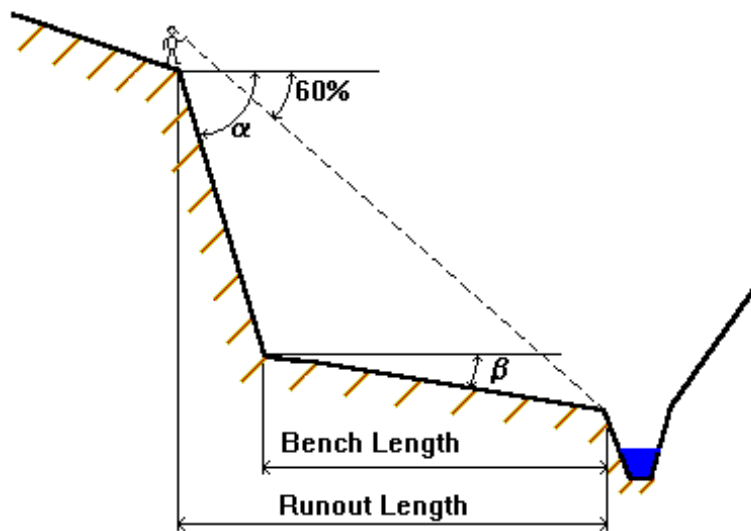
#### ***Private lands***

First, identify any slopes steeper than 70%. These are the slopes with a potential for failure and delivery. (If slopes are less than 70%, standard rules will apply to harvest and road construction projects.) If no delivery is predicted by using one of the following methods, then standard rules apply. If delivery *is* predicted, use prescriptions for MW-2.

For potential failure slopes over 70%, proceed to the following steps to determine whether sediment generated by potential mass wasting could be delivered to stream channels. This is determined by assuming that all soils that lie above any 60% grade line extending upward from any stream will deliver to the channel, and be routed to a vulnerable stream segment. (This delivery will of course occur *only* if landslides are generated on the slope steeper than 70%.) There are two types of methods to determine if a potential failure slope can deliver:

**1. Visual:** The most direct method to determine if a potential failure slope may deliver is to measure the vertical angle between the top of the potential failure slope and the OHWM (*see sketch below*). To do this, stand at the break in slope (where the slope above is less than 70%) and shoot to the closest edge of the OHWM with your clinometer. If the vertical angle is less

## BENCHES TO PREVENT DELIVERY



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*H-58*

a. The *exact formula* uses trigonometry so a calculator is required. The exact formula is:

$$\text{Required Bench Distance} = \text{Runout} * [\text{Sin}(\alpha^\circ - 31^\circ)] * [\text{Cos}(\beta^\circ)] \\ \text{-----} \\ (0.8575) * [\text{Sin}(180^\circ + \beta^\circ - \alpha^\circ)]$$

b. The *simplified formula* does not require trigonometry, so it can be calculated easily in the field. The simplified formula is:

$$\text{Required Bench Distance} = \text{Runout} * [(\text{failure \%} - 0.7) + (\text{bench \%})]$$

The simplified formula overestimates the required bench distance by less than 10% for bench slopes between 20-40%, which leads to a conservative estimate. It underestimates the required bench distance by less than 10% for bench slopes less than 20% or greater than 40%.

The following notes apply to both formulas above:

- All distances are horizontal and measured in feet.
- All slope angles are measured in degrees or decimal percent (as specified in the formula).
- Runout is the total horizontal distance from the top of the potential failure slope to the OHWM.
- Required Bench Distance is the minimum horizontal distance of bench in feet, required to stop delivery from the potential failure slope.
- If the actual bench distance measured in the field is greater than the Required Bench Distance, then NO delivery potential is assumed and standard rules apply. If the actual bench distance is less than the Required Bench Distance, then DELIVERY potential is assumed, and prescriptions for MW-2 will apply.
- These formulas are based on the assumption that all material laying above a 60% grade line extending upward from a channel edge will deliver. This is based on the watershed analysis Mass Wasting module's CMRs.

#### **TECHNICAL RATIONALE**

These isolated high-hazard areas, which belong in MW-2, but are not identifiable remotely, were observed in several locations in the field. The hazards associated with them are addressed in the prescriptions for MW-2.

## MW-2

**DESCRIPTION:** roading and harvesting on slopes steeper than 70% in MWMUs 1 & 2b

**Applicable MWMU:**

- 1 Gorges
- 2b Alluvial Valley Walls (actively undercut)

**RULE CALL:** Prevent /Avoid (ARS Map Unit 2)

**hazard delivery rating:** high

**resource vulnerability:** high (sediment delivered directly, or routed via other GMUs, to GMU 1, 2, 6 or 7)

### SITUATION SUMMARY

<b>Input:</b>	Coarse and fine sediment ( <i>fine sediment in GMU 2, 7, 9 only</i> )
<b>Time Frame:</b>	from past, present, and future
<b>Process:</b>	mass wasting
<b>Activity:</b>	associated with roads and clearcut harvesting
<b>Location:</b>	on slopes steeper than 70% in MWMUs 1 and 2b
<b>Channel Effects:</b>	may cause channel avulsion, aggradation, increased depth of scour, loss of surface flow, increased pool spacing, loss of LWD function, and increased stream bank erosion, causing
<b>Resource Effects:</b>	lower reproductive success for fall spawning species, possibly delayed migration in dry years, stranding in isolated pools and/or death in the dry stream of juvenile salmonids, lower summer and winter survival, fewer large trout in rearing populations, fewer coho and cutthroat juveniles. Coarse sediment can also threaten the County-maintained Swift and Vance Creek bridges, and the Skokomish Valley Road.

### TRIGGERING MECHANISM

**Clearcut harvesting** can reduce the root reinforcement holding unstable soils on the slope.

**Roads** may increase failure rates in these units because:

**Culverts** can be blocked by sediment and woody debris in streams, leading to fill saturation and failure.

**Stream crossings** can contain large amounts of fill that can fail if saturated.

**Sidecast road fills** can become unstable if placed on organic materials, not compacted, or not keyed into (or otherwise anchored onto) the slope.

**Steep road cuts** can lead to cut-slope failures.

**Exposed cut and fill soils** can ravel or fail if not vegetated or otherwise stabilized.

**Wide ditch relief spacing** can direct large volumes of water onto unstable or easily eroded slopes.

**Infrequent road maintenance** can allow ditches to fill and culverts to plug causing slope saturation or erosion.

### COMMENTS

Mass wasting events in these units tended to initiate on slopes with local gradients of at least 70%. This 70% cut-off is derived from the slope gradients in the initiation area and is fairly conservative because it was based on hillslope scale gradients and landslides tend to initiate on steeper subsections of slope.

Harvesting of a tree on these slope will reduce the root reinforcement and increase instability unless the tree's nearest neighbors can replace the harvested tree's sapwood basal area (or leaf biomass) before the smaller roots of the harvested tree can decay (within five years). If the local canopy regains its pre-harvest closure within five years of the harvest, the integrity of the root network can be assumed to have been maintained. (Note: mass wasting can still occur even if root reinforcement is maintained, because these slopes fail in the absence of management.)

Given the variability in instability, delivery, and soil of these slopes, geotechnical inspection of road alignment and construction may be useful in identifying potential triggering mechanisms so road instability can be prevented or avoided. A road maintenance and repair plan can be adopted to identify and fix or prevent the above triggering mechanisms.

### **MANAGEMENT OBJECTIVES**

Allow partial harvest on the few slopes within these MWMUs which are stable enough to be harvested without triggering mass wasting. Preserve the option to build roads crossing these units when necessary and when it can be done without triggering mass wasting.

### **PRESCRIPTIONS**

#### ***Public (federal) lands***

Projects and activities shall be consistent with the Aquatic Conservation Strategy. These objectives are outlined in the Record of Decision (ROD, B-11 and C-31).

Prescribed widths of Riparian Reserves apply until a site specific analysis is conducted and described and the rationale for final Riparian Reserve boundaries is presented through the appropriate NEPA decision-making process, ROD C-30.

On public lands, a detailed analysis of existing and potential erosion sites has been completed. Using this, and other related information, an Access and Travel Management Plan (ATM) was developed and submitted to the District Manager for review and approval. This plan outlines activities to prevent high delivery of fine sediments from road surfaces, cut banks, and fill slopes.

***Private lands***

**Harvest**

***Option 1***

Partial harvest; prepare a geotechnical report, to be approved by DNR, (see addendum) with recommendations for maintaining slope stability at pre-harvest levels after tree removal.

***Option 2***

Allow for 25% removal of dominant and co-dominant trees every 10 years, maintaining even crown closure or stem spacing as much as possible. Experiment with no more than 5% of applicable area ever 5 years, until this method is found acceptable; if not found acceptable, harvest in these areas shall stop.

**Roads**

Roads shall not be permitted unless planned in consultation with a geotechnical expert (see addendum) and will be permitted only if it can be shown that the road will not trigger landslides. The report of the geotechnical expert shall include recommendations addressing: drainage patterns, culvert sizing, fill placement (if any), disposal of spoils, maintenance and/or abandonment plans, and any other factors affecting slope stability.

***Note:*** Road maintenance plans have been developed for the South Fork Skokomish WAU, All maintenance activities shall be in accordance with this plan.

**TECHNICAL RATIONALE**

Most of these slopes are unstable or only marginally stable, and delivery is immediate. However, there may be areas mapped as MWMU 1 or 2b from which trees may be safely harvested without endangering slope stability. The experimental harvest scheme permitted by Option 2 would allow for assessing the amount of harvest allowable for maintaining root strength sufficient for maintaining stability at pre-harvest levels.

## MW-3

**DESCRIPTION:** Harvesting and roading on 70% slopes-above a 60% line extending from streams in MWMUs 2a, 6, & 8a and actively unstable slopes (as described below)

**Applicable MWMU:**

- 2a Valley walls
- 6 Glacial uplands
- 8a Glacial valley slopes (found only on USFS lands)

**RULE CALL:** Minimize (ARS Map Unit 3a) or Prevent/Avoid (ARS Map Unit 3b)

**hazard delivery rating:** moderate

**resource vulnerability:** moderate (Eells Hill Road; GMU 9 where delivery may be direct or via GMUs 12.1 or 12.2); high (GMUs 1, 2, 6, 7, routing from various GMUs and the Eells Spring Hatchery).

### SITUATION SUMMARY

- Input:** Coarse and fine sediment (*fine sediment in GMU 2, 7, 9 only*)
- Time Frame:** from past, present, and future
- Process:** mass wasting
- Activity:** associated with clearcut harvesting and roading
- Location:** near streams in otherwise poorly delivering MWMUs 2a, 6, & 8, and the county-maintained Eells Hill Road
- Channel Effects:** may cause channel avulsion, aggradation, increased depth of scour, loss of surface flow, increased pool spacing, loss of LWD function, and increased stream bank erosion causing
- Resource Effects:** lower reproductive success for fall spawning species, possibly delayed migration in dry years, stranding in isolated pools and/or death in the dry stream of juvenile salmonids, lower summer and winter survival, fewer large trout in rearing populations, fewer coho and cutthroat juveniles. Coarse sediment can also threaten the Eells Spring Hatchery intakes and hatchery itself, Eells Hill Road, the County-maintained Swift and Vance Creek bridges, and the Skokomish Valley Road.

### TRIGGERING MECHANISMS

**Clearcut harvesting** can reduce the root reinforcement holding unstable soils on the slope.

**Roads** may increase failure rates in these units because:

**Culverts** can be blocked by sediment and woody debris in streams, leading to fill saturation and failure.

**Stream crossings** can contain large amounts of fill that can fail if saturated.

**Sidecast road fills** can become unstable if placed on organic materials, not compacted, or not keyed into (or otherwise anchored onto) the slope.

**Steep road cuts** can lead to cut-slope failures.

**Exposed cut and fill soils** can ravel or fail if not vegetated or otherwise stabilized.

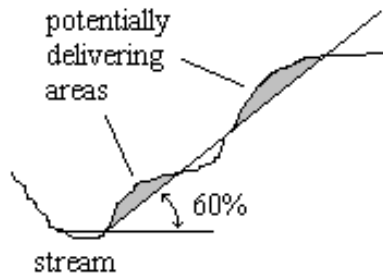
**Ditch relief spacing** greater than half of the local swale spacing can direct large volumes of water onto unstable or easily eroded slopes.

**Infrequent road maintenance** can allow ditches to fill and culverts to plug causing slope saturation or erosion.

### COMMENTS

Much of the terrain to which this CMR applies has a modest history of mass wasting and low potential for delivery. Within these slopes, landslides tended to initiate on slopes with local gradients of at least 70%. (This 70% cut-off is derived from the slope gradients in the initiation area and is fairly conservative because it was based on hillslope scale gradients and landslides tend to initiate on steeper subsections of slope.) The area in which prescriptions should be applied are those where delivery is likely.

For slopes below these slopes greater than 70% only: in MWMUs 2a and 6, most areas with delivery potential are near stream channels on steep slopes created by stream channel incision of glacial sediment. The sections of these units which deliver to the stream network (*if* a landslide is triggered) might best be defined as all soils that lie above any 60% slope extending from any stream in these MWMUs (see sketch).



Road alignments and construction standards which address the above triggering mechanisms should be able to minimize additional sediment delivery to the stream network, which would prevent sediment delivery of sufficient magnitude to have a significant adverse impact on vulnerable channels given the high background sediment delivery rates. A road maintenance and repair plan can be adopted to identify and fix or prevent the above triggering mechanisms.

Harvesting is associated with an increased incidence in mass wasting in these units, which suggests that root reinforcement may maintain the stability of these slopes. Post-harvest loss of root reinforcement might be minimized through promoting advance regeneration, tolerating competing brushy vegetation (and the root reinforcement it provides), and rapid replanting at elevated density, followed by lighter and more frequent pre-commercial thinning. These measures would prevent significant adverse effects on vulnerable stream segments.

### **MANAGEMENT OBJECTIVES**

Prevent sediment delivery to stream channels resulting from management activities.

## **PRESCRIPTIONS**

### ***Public (federal) lands***

Projects and activities shall be consistent with the Aquatic Conservation Strategy. These objectives are outlined in the Record of Decision (ROD, B-11 and C-31).

Prescribed widths of Riparian Reserves apply until a site specific analysis is conducted and described and the rationale for final Riparian Reserve boundaries is presented through the appropriate NEPA decision-making process, ROD C-30.

On public lands, a detailed analysis of existing and potential erosion sites has been completed. Using this, and other related information, an Access and Travel Management Plan (ATM) was developed and submitted to the District Manager for review and approval. This plan outlines activities to prevent high delivery of fine sediments from road surfaces, cut banks, and fill slopes.

### ***Private lands***

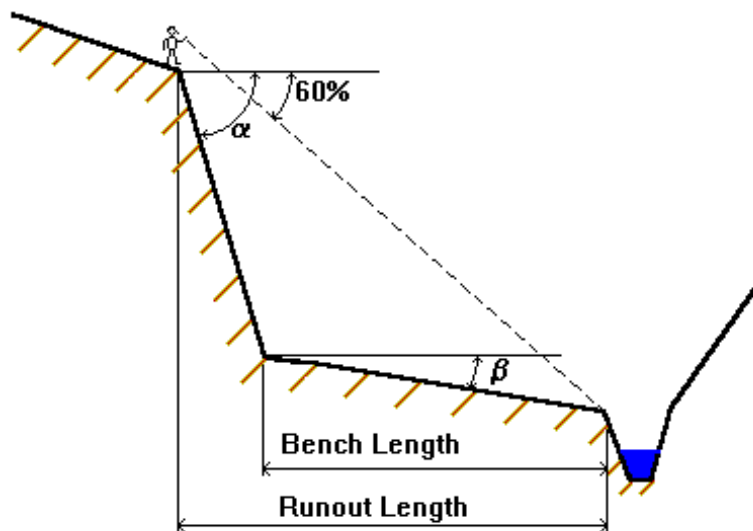
First, identify any slopes steeper than 70%. These are the slopes with a potential for failure and delivery. (If slopes are less than 70%, standard rules will apply to harvest and road construction projects.) If no delivery is predicted by using one of the following methods, then standard rules apply. If delivery *is* predicted, use prescriptions following this formula.

For potential failure slopes over 70%, proceed to the following steps to determine whether sediment generated by potential mass wasting could be delivered to stream channels. This is determined by assuming that all soils that lie above any 60% grade line extending upward from any stream will deliver to the channel, and be routed to a vulnerable stream segment. (This delivery will of course occur *only* if landslides are generated on the slope steeper than 70%.)

There are two types of methods to determine if a potential failure slope can deliver:

- 1. Visual:** The most direct method to determine if a potential failure slope may deliver is to measure the vertical angle between the top of the potential failure slope and the OHWM (see sketch below). To do this, stand at the break in slope (where the slope above is less than 70%) and shoot to the closest edge of the OHWM with your clinometer. If the vertical angle is less than 60%, then NO delivery potential is assumed and standard rules will apply. If the vertical angle is greater than 60%, then DELIVERY potential is assumed and prescriptions will apply.
- 2. Calculated:** For cases where you cannot see the OHWM and there is a defined bench below the potential failure slope, either of the following two formulas can be used to determine the minimum required bench distance to stop delivery from the potential failure slope. These formulas require measurements of the horizontal distance from the top of the slope to the OHWM (termed “runout”), the slope of the potential failure slope ( $\alpha$  in % or degrees), and the actual bench slope ( $\beta$  in % or degrees) and actual bench distance to compare to the Required Bench Distance (see sketch on the next page).

**BENCHES TO PREVENT DELIVERY**



$\alpha$  = Potential Failure Slope (must be  $> 70\%$ )  
 $\beta$  = Bench Slope (must be  $< 60\%$ )  
Runout = Horizontal Distance  
Bench = Horizontal Distance

a. The *exact formula* uses trigonometry so a calculator is required. The exact formula is:

$$\text{Required Bench Distance} = \text{Runout} * [\text{Sin}(\alpha^\circ - 31^\circ)] * [\text{Cos}(\beta^\circ)] \\ \text{-----} \\ (0.8575) * [\text{Sin}(180^\circ + \beta^\circ - \alpha^\circ)]$$

b. The *simplified formula* does not require trigonometry, so it can be calculated easily in the field. The simplified formula is:

$$\text{Required Bench Distance} = \text{Runout} * [(\text{failure \%} - 0.7) + (\text{bench \%})]$$

The simplified formula overestimates the required bench distance by less than 10% for bench slopes between 20-40%, which leads to a conservative estimate. It underestimates the required bench distance by less than 10% for bench slopes less than 20% or greater than 40%.

The following notes apply to both formulas:

- All distances are horizontal and measured in feet.
- All slope angles are measured in degrees or decimal percent (as specified in the formula).
- Runout is the total horizontal distance from the top of the potential failure slope to the OHWM.
- Required Bench Distance is the minimum horizontal distance of bench in feet, required to stop delivery from the potential failure slope.
- If the actual bench distance measured in the field is greater than the Required Bench Distance, then NO delivery potential is assumed and standard rules apply. If the actual bench distance is less than the Required Bench Distance, then DELIVERY potential is assumed, and prescriptions following will apply.
- These formulas are based on the assumption that all material laying above a 60% grade line extending upward from a channel edge will deliver. This is based on the watershed analysis Mass Wasting module's CMRs.

### **Harvest**

If no delivery is predicted, standard rules apply. If delivery is predicted from the above steps, choose one of the following options.

#### ***Option 1***

**No harvest** on delivering slopes.

#### ***Option 2 (Harvest methods based on site conditions as follows)***

##### **Stable slopes:**

Clearcutting is permitted on slopes which have the following characteristics indicating stability:

1. High density of conifer (greater than 100 trees per acre) indicating well-drained soils;
2. Non-convergent topography;
3. No landslide scars or mapped historic slides.

##### **Potentially unstable slopes:**

Selective harvest (up to 50% removal, representative of size and species of pre-harvest stand, evenly distributed on the slope) where there are one or more of the following signs of *potential* instability:

1. convergent and wet
2. deciduous trees, organic soils or seeps, wetland vegetation (density of conifer <100 trees per acre)
3. clusters of pistol butted trees

**Unstable areas:**

No harvest, with a 20' no-cut buffer around area of instability even if slopes are <70%, there is a potential for delivery, and one or more of the following indications of *active* instability occur:

1. active slides or evidence of historic slides;
2. jackstrawed trees;
3. scarps or tension cracks.

Yarding corridors will be permitted in the 20' buffers around these areas with indications of active instability, where such corridors will aid slope stability more than harvest without the corridors.

**Roads**

- No roads on unstable areas (as defined above);
- Minimize road length on delivering slopes;
- No sidecast construction or sidecast maintenance;
- Culverts one size above 100-yr flood;
- Minimize fill;
- Maintain drainage patterns (recommend installing driveable dips);
- Identify suitable disposal areas to be approved by DNR;
- Mid-slope roads should be temporary or have a maintenance plan;
- Mass wasting deposits on the road surface are to be removed offsite and natural drainage functions to be restored as quickly as possible during rainy season or prior to October 1, should the failure occur during the summer;
- Provide road maintenance plan (such plans already exist for Simpson and Federal lands).

**Recommendation** for site productivity: revegetate riparian areas as road is being constructed.

**Note:** Road maintenance plans have been developed for the South Fork Skokomish WAU, all maintenance activities shall be in accordance with this plan.

**TECHNICAL RATIONALE**

Through much of this unit, sediment from mass wasting will not be delivered, so delivery is the first concern. Where slopes are sufficiently steep and delivery is possible, hazard is variable and the prescriptions address this variability.

It is recommended that prescriptions are evaluated during the five-year review process to ensure that slope stability is being retained.

*Specific prescriptions:*

- The team agreed that a 50% retention of trees should retain adequate root strength to maintain slope stability. The prescriptions were developed following several on-site visits and considering the harvesting comments (on page 16).
- The 20' buffer around unstable areas should avoid compromising root strength within the unstable areas.

## MW-4

**DESCRIPTION:** harvesting on slopes >70% grade, and roading on slopes >60% in MWMUs 7a & 7b

**Applicable MWMUs**

- 7a Headwater slopes
- 7b Headwater slopes with overlying glacial deposits

**RULE CALL:** prevent/avoid for roads

minimize for other areas (both rule calls may apply in ARS Map Unit 4)

**hazard delivery rating:** moderate for non-road-related triggering mechanisms which account for 28% of delivered sediment from management-related mass wasting, high for road-related triggering mechanisms which account for 72% of delivered sediment from management related mass wasting

**resource vulnerability:** high (sediment is routed to GMUs 1, 2, 6, or 7 directly or via other GMUs)

### SITUATION SUMMARY

- Input:** Coarse sediment
- Time Frame:** from past, present, and future
- Process:** mass wasting
- Activity:** associated with roads and harvesting
- Location:** on steep headwater slopes (MWMU 7a and b)
- Channel Effects:** may cause channel avulsion, aggradation, increased depth of scour, loss of surface flow, increased pool spacing, loss of LWD function, and increased stream bank erosion.
- Resource Effects:** lower reproductive success for fall spawning species, possibly delayed migration in dry years, stranding in isolated pools and/or death in the dry stream of juvenile salmonids, lower summer and winter survival, fewer large trout in rearing populations, fewer coho and cutthroat juveniles. Coarse sediment can also threaten the Eells Spring Hatchery intakes and hatchery itself, Eells Hill Road, the County-maintained Swift and Vance Creek bridges, and the Skokomish Valley Road.

### TRIGGERING MECHANISM

The following list specifies forest practices that typically play a role in triggering mass wasting events.

**Harvesting** reduced the root reinforcement holding unstable soils on the slope.

**Roads** may increase failure rates in these units because:

**Culverts** can be blocked by sediment and woody debris in streams, leading to fill saturation and failure.

**Stream crossings** can contain large amounts of fill that can fail if saturated.

**Sidecast spoils and road fills** can become unstable if placed on organic materials, not compacted, or not keyed into (or otherwise anchored onto) the slope.

**Steep road cuts** can lead to cut-slope failures.

**Exposed cut and fill soils** can ravel or fail if not vegetated or otherwise stabilized.

**Wide ditch relief spacing** can direct large volumes of water onto unstable or easily eroded slopes.

**Infrequent road maintenance** can allow ditches to fill and culverts to plug causing slope saturation or erosion.

The mass wasting inventory (Form A-1) was utilized to generate additional information about mass wasting initiation sites to focus on the portions of the landscape and the triggering mechanisms which have delivered the most sediment to vulnerable waters. Since the mass wasting inventory is a Level 2 data base, sediment production volumes have been calculated, and the proportion of delivery from various triggering mechanisms or landscape positions can be compared quantitatively. Hazard ratings for this MWMU were based in part on the following.

1. Road-related mass wasting, including road crossing failures and landing failures, accounts for 72% of the delivered volume of sediment. The vast majority of this sediment is delivered by mass wasting events that were initiated within 500 horizontal feet of stream channels.
2. Non-road-related near-channel initiation sites account for 10% of the delivered volume of sediment. Road-related near channel initiation sites contributed 22% of delivered sediment.
3. Non-road-related (clear-cut) initiation sites account for 18% of delivered sediment. An undetermined, but likely substantial, portion of these initiation sites are “headwalls”.
4. Initiation sites on convergent slopes generated 33% of delivered sediment; planar slopes generated 59% of delivered sediment.
5. Debris flows account for 28% of delivered sediment volume. Road-related triggers and harvest-related triggers each contribute half of the delivered sediment from debris flows.

### **COMMENTS**

Mass wasting events in these units tended to initiate on slopes 70% or steeper. Typical hillslopes adjacent to channels are typically between 85 and 90%, and observed maximum hillslopes adjacent to surveyed streams in GMU 11 are typically 95-100%.

Road alignments and construction standards which address the above causal mechanisms should be able to minimize additional sediment delivery to the stream network, which would prevent significant adverse effects on vulnerable stream segments.

Harvesting is associated with an increased incidence in mass wasting in these units suggests that root reinforcement may maintain the stability of these slopes. Post-harvest loss of root reinforcement might be minimized through promoting advance regeneration, tolerating competing brushy vegetation (and the root reinforcement it provides), and rapid replanting at elevated density, followed by lighter and more frequent pre-commercial thinning. These measures would prevent significant adverse effects on vulnerable stream segments.

Ninety percent of sediment delivery from initiation sites on convergent topography originated within 500 ft of stream channels. On planar slopes, 90% of delivered sediment originated from sites within 300 ft of stream channels.

### **PRESCRIPTIONS**

#### ***Public (federal) lands***

Projects and activities shall be consistent with the Aquatic Conservation Strategy. These objectives are outlined in the Record of Decision (ROD, B-11 and C-31).

Prescribed widths of Riparian Reserves apply until a site specific analysis is conducted and described and the rationale for final Riparian Reserve boundaries is presented through the appropriate NEPA decision-making process, ROD C-30.

On public lands, a detailed analysis of existing and potential erosion sites has been completed. Using this, and other related information, an Access and Travel Management Plan (ATM) was developed and submitted to the District Manager for review and approval. This plan outlines activities to prevent high delivery of fine sediments from road surfaces, cut banks, and fill slopes.

#### ***Private lands***

##### **Harvest**

- For all clearcut slopes steeper than 70%, promote rapid regeneration of root strength by replanting at 450 trees per acre in the first year after harvest.
- Corridors will be allowed if necessary for operations
- No broadcast burning

The following additional prescriptions apply to specific high hazard areas:

1. ***Near-channel areas*** below a defined break in slope (defined as a change greater than 20%) and slopes steeper than 70%, extending 250' (75 m) from the channel.
  - 30' (10 m) no-cut buffer
  - Full suspension below break in slope; partial suspension (full if feasible) above break in slope
2. ***Headwalls*** (upslope area draining to a channel head) within 500' of a channel, even if less than 70%.
  - Partial suspension (full suspension where feasible)
  - Partial cut (leaving 100 trees per acre larger than 5" dbh)

##### **ROADS**

- Minimize road construction on headwalls and near-channel areas and cross streams at 90° angles;
- No sidecast construction or sidecast maintenance;
- Consult a geotechnical expert (see addendum) if glacial sediments are encountered;
- Culverts one size above 100-yr flood;
- Minimize fill;
- Maintain drainage patterns (recommend installing driveable dips);
- Identify suitable disposal areas to be approved by DNR;
- Mid-slope roads should be temporary or have a maintenance plan;
- Mass wasting deposits on the road surface are to be removed offsite and natural drainage functions to be restored as quickly as possible during rainy season or prior to October 1, should the failure occur during the summer;
- Provide road maintenance plan (such a plans already exist for Simpson and Federal lands).

**Recommendation** for site productivity: revegetate riparian areas as road is being constructed

**Note:** Road maintenance plans have been developed for the South Fork Skokomish WAU, All maintenance activities shall be in accordance with this plan.

##### **TECHNICAL RATIONALE**

The majority of sediment delivery attributable to forest practices in these areas is from roads or landings (72%). These prescriptions are designed to prevent or avoid adverse impacts to public resources by preventing additional sediment delivery from roads, and minimizing mass wasting attributable to timber harvest, which accounts for 28% of delivered sediment in MWMUs 7a & 7b.

High hazard areas defined above were based on data for mass wasting runout lengths and/or proportions of delivered sediment derived from the mass wasting inventory.

The hazard area described in 1. above:

**Near-channel areas** below a defined break in slope (defined as a change greater than 20%) was based on field observations of oversteepened near-channel hillslopes and the fact that near-channel initiation sites accounted for 32% of delivered sediment in MWMUs 7a & 7b; 10% of delivered sediment originated from initiation sites in near-channel clear-cut areas. **and slopes steeper than 70%**, extending 250' (75 m) horizontally from the channel was identified based on the average mass wasting runout length for clear-cut (non-road) initiation sites on planar hillslopes. 18% of delivered sediment came from clear-cut areas not located adjacent to channels, and an undetermined but substantial portion of the 18% originates in headwall areas addressed below.

The hazard area described in 2. above:

**Headwalls** (zero-order basins draining to a channel head) within 500' horizontally of a channel was identified by the average mass wasting runout initiated in convergent topography. Although there were longer runouts, portions of the length of these likely occurred in unmapped channels. Field experience in the area indicates that headwall areas are very unlikely to be more than 500 ft from a channel.

Headwall hazard areas may be identified according to the following description:

Headwall areas are located in the vicinity of the channel head of small, steep Type 4 or 5 streams. They are characterized by steep slopes and convergent topography, with valley side slopes >70%. Headwalls above or at the channel head typically have slopes >70% and may have bedrock outcrops. The channel slope near the channel head will often be <70%, but a high hazard of mass wasting exists in this lower-gradient near-channel zone because of a high seasonal water table, accumulated soil and debris in the swale which is the material most likely to fail, and underlying bedrock at shallow depth that restricts downward percolation of water. Locations such as these are likely initiation sites for shallow rapid mass wasting with a high likelihood of debris flow. Headwall hazard areas are likely to be contiguous with hazard zones associated with near-channel slopes >70%, including inner gorge slopes, extending upstream along better-defined Type 4 channels. Root strength in the lower gradient headwall swales with accumulated soil and debris is particularly important for slope stability.

The following table shows how the prescriptions address the triggering mechanisms identified in the causal mechanism report.

<i>Triggering mechanism</i>	<i>% of sediment delivery</i>	<i>How prescriptions address triggering mechanisms</i>
Roads	72	road construction and maintenance rules
Harvest (near channel)	10	10 m (30') no-cut buffer and rapid replanting
Harvest (headwalls)	14	partial cut
Harvest (not near channel)	4	rapid replanting

## **Appendix I: List of Contributors and Advisors**

Many people from diverse professional backgrounds participated in the process of developing this HCP. The discussions and debates touched virtually every element of forest land management and resource protection. As would be expected from such a diverse group of individuals, highly divergent views were often voiced. These views, while not always compatible, were effective in airing the issues and balancing the discussion. Although we understand that not all of the participants will endorse each aspect of this HCP, Simpson appreciates the sincerity and energy that was brought to bear on this process by all parties and wishes to recognize their contributions.

E. Keith Simmons	Simpson, Project management
N. Phil Peterson	Simpson, Riparian, fish, amphibians
Gary Schuyten	Simpson, Operational evaluation
Dave Backstrom	Simpson, Operational evaluation
Bob Rogers	Simpson, GIS support and forest inventory
Rick Schmelling	Simpson, GIS support and maps
Joe Breed	Simpson, Legal affairs
Ian Stewart	Simpson, Riparian, fish, amphibians (currently Univ. of Washington)
Greg Schroer	Wildlife, Resources Northwest, Inc.
Jeff VanDuzer	Legal affairs and IA; Davis Wright Tremaine
Chris Mendoza	Aquatic Restoration Consultants, Riparian, fish, amphibians
Lynne Rodgers Miller	M2 Environmental, Document editing and production
Steve Landino	National Marine Fisheries Service
Mike Parton	National Marine Fisheries Service
Kathy Cushman	U. S. Fish and Wildlife Service
Linda Saunders-Ogg	U. S. Fish and Wildlife Service
Bill Vogel	U. S. Fish and Wildlife Service
Phil Millam	Environmental Protection Agency
Bruce Cleland	Environmental Protection Agency
Steve Ralph	Environmental Protection Agency
Vern Stelter	Washington Dept. of Fish and Wildlife (currently Wyoming Dept. Fish and Game)
Greg Volkhardt	Washington Dept. of Fish and Wildlife
David Whipple	Washington Dept. of Fish and Wildlife
Nora Jewett	Washington Dept. of Ecology
Charles Toal	Washington Dept. of Ecology
John Edwards	Washington Dept. of Natural Resources
Tim Cullinan	National Audubon Society
Michelle Stevie	Squaxin Island Tribe
Jeff Dickison	Squaxin Island Tribe
Jim Park	Skokomish Indian Tribe
Marty Ereth	Skokomish Indian Tribe
Mark Mobbs	Quinault Indian Nation
Carol Bernthal	Point-No-Point Treaty Council
Sally Nickleson	Point-No-Point Treaty Council
Bruce Davies	Northwest Indian Fisheries Commission
Janet Burcham	Northwest Indian Fisheries Commission